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China Report

SCIENCE AND TECHNOLOGY

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CHINA REPORT
SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

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NATIONAL DEVELOPMENTS

MICROELECTRONIC TECHNOLOGY TO IMPROVE INSTRUMENTATION

Shanghai ZIDONGHUA YIBIAO [PROCESS AUTOMATION INSTRUMENTATION] in Chinese
20 Sep 84 p 6

[Article by Wei Yangan [5898 7122 1344] Wuhan Institute of Instruments and Meters]

[Text] The instrumentation devices industry will accelerate automation technology; only in striving for improvement in quality can we actually fulfill the new products requirements of the national economy, and guarantee improvement of existing products. Danfoss of Denmark makes cryogenic self-regulating devices which are basically identical or almost identical in structure to those produced in China. But there is a big difference in reliability of their products as compared to ours. For example, the operating life of the switches used in Chinese pressure and temperature controllers is about 20,000 operations as compared to 400,000 for similar Danfoss products, and actually the specification requirement is for 1 million. The reason that Danfoss products can reach this level hinges on many guaranteed conditions. Two are worthy of our scrutiny: One, the advanced level of its parts machining technology--the principal work processes mostly utilize automatic control or computer control, thereby assuring that parts meet machining precision and functional requirements. The other, Danfoss has more complete testing procedures and equipment to assure product quality. The specialized testing equipment is all designed and developed in-house, some even have computer connections, and these specialized pieces of equipment are very suitable for control of the production processes. In this respect, they are willing to invest and put forth effort, and, as a result, their products have earned consumer confidence in the international market. For many years, their cryogenic self-regulating instrumentation devices have kept about 40 percent of the total sales volume in the international market.

In light of this situation, our instrumentation device enterprises should not only quickly introduce microelectronic technology into their own products but should also guide this technology in progress in its own field. This is to improve technological quality and level of our enterprises help us do our best to coordinate the development of products, technology, and microelectronics and to basically narrow the gaps, in the same fields, between our country and others.

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CSO: 4008/232

NATIONAL DEVELOPMENTS

CONTENT OF REPORT ON PROVINCIAL S&T SITUATION

Kunming YUNNAN RIBAO in Chinese 12 Oct 85 p 2

[Text] On the morning of 8 October Huang Aoluo [1728 2407 5012], director of the provincial science and technology [S&T] system, gave a "Report on the Situation Regarding Restructuring of the Science and Technology System in This Province" at the 17th Session of the Standing Committee of the 6th Provincial People's Congress. An abstract follows:

The "Report" spoke of the situation for progress and development in the restructuring of the science and technology system. The "Report" said that after the proclamation of the "Resolution by the CPC Central Committee Regarding the Restructuring of the Science and Technology System," the provincial government held an all province science and technology working conference in the latter part of May, which made up a full scale plan for the restructuring of the science and technology system. At that time, the primary things taken up were as follows: 1) organize the cadre to study the "Resolution," pass on the spirit of the all province science and technology working conference, and unite all areas and units into actual study and drafting of a restructured system and program; 2) the majority of research institutes carried out some reforms of varying degrees, which stimulated the integration of research with production, and which was a positive factor in industrial and agricultural production, especially for advances in small and medium enterprise technology. At the same time, ten research institutes have already begun to be self sufficient through service fees; 3) technical service of all sorts has developed vigorously, and the technology markets are quite lively. 4) A number of research, teaching, and production units have set up more than 30 research-production joint organizations, which have increased the development capacity of enterprise technology.

The "Report" stressed short-term arrangements for the restructuring of the science and technology system of this province, chief among which are:

1. Reforming the funds allocation system to gradually change the situation whereby the state is too encompassing and controls too tightly. Changing the funds management methods for the 130 independent research institutes throughout the province that differ in conditions. Thirty-one technology development institutes among them have gradually eliminated service fees. Considering that the majority of the institutes in our province are basically

weak, it has been decided that of the service fees reduced in allocation during the seventh 5-Year Plan, one-half would be returned to the original unit, and one-half would be put into various levels of science and technology development funds to be used for science and technology service. For 28 social welfare or technical service research institutes, the state will continue to allocate service fees, there will be an outlay responsibility system, and at the same time they will actively organize income accumulation funds. For 71 agriculture, forestry, animal husbandry, by-products, and fishery sciences institutes, the state will provide service fees, and they will implement an outlay responsibility system to encourage them to actively organize an autonomous income. Six institutes among them will become free of service fees, and the majority or totality of the service fees that are reduced in allocation for them will be returned to the original units to be used in improving the conditions for agriculture science research.

To invigorate scientific research and further enhance and develop scientific and technical service, research funds in this province during the seventh 5-Year Plan ought to be not less than the average rate of growth during the sixth 5-Year Plan, increasing annually. Beginning next year, capital construction funds for research units will be provided in portions. Step by step and in a planned way, a group of major research institutes will be outfitted to help build up a number of local, prefectural, and municipal level technology markets. The province is also prepared to allocate a technology exploitation fund to act as a compensation discount for supporting major technology exploitation projects. Credit plans of all levels ought to arrange guidelines for science and technology loans to support scientific and technical service.

2. Expedite the restructuring of scientific research institutes. Faced with the fact that the restructuring of the research institutes in this province will develop unevenly, and the situation that some policies are not clear or are not implemented, the provincial government will issue "Temporary Provisions Regarding Some Problems in the Restructuring of Scientific Research Institutes" to promote more development in institute restructuring. During the seventh 5-Year Plan, the province is prepared to help 17 province affiliated technology exploitation research institutes establish testing workshops, and the province will work with prefectures and autonomous prefectures to help affiliated agricultural research units establish bases for experimentation and demonstration. To develop the products that are an advantage to this province, we will first of all set up the Liangyan Research and Development Center to create research and development centers or bases by stages and groups for dominant resources like spices, medicinal materials, flowers and plants, subtropical fruits, and winter and spring early vegetables. At the same time, they will study scientific and technical development strategies for Yunnan that will gradually form reasonable basic research, applications research, and technical development research organizations with Yunnan characteristics.

3. Vigorously exploit technology markets. In addition to large scale comprehensive technology fairs held at regular intervals, we will establish a group of technology exchanges and development organizations. First of all, we will take care of the ten permanent technology markets that have already begun

operation, and we will clear up and reorganize the various civilian science and technology companies (centers) to genuinely serve economic construction. We will provide support in the aspects of funding, loans, and tax revenue for technology transactions and technology development projects.

4. Enhance enterprise capacity for the absorption and development of technology. Capacities for the absorption and development of technology by enterprises in this province are weak, so we must restructure the current enterprise science and technology system to achieve the three implementations of tasking, organization, and outlay. Large and medium scale enterprises should strengthen their departments of technology development and establish their own research institutes (laboratories); small enterprises should join together to set up technology development organizations, or establish various forms of joint organizations with scientific research or educational units, all of this to strengthen enterprise capacities for technology absorption and development. Enterprise science and technology should serve the remolding of traditional technology, the overcoming of technical difficulties, the broadening of technical achievements, the development of new products, and the seeking of superiority, a recognized name, and foreign currency, and should also organize technology education and technology training and improve the quality of their staffs. They should select more mature yet valuable "short, even, fast" technical projects, concentrate energies, stress breakthroughs, and drive on advances in town and township enterprise technology.

5. Gradually restructure the agricultural science and technology system. The current agriculture and technology system is not reasonable, it is fractured, dispersed, and to a great degree restricts the development of current capacities. To suit adjustments to agricultural production structures and the requirements of agricultural specialization, commercialization, and modernization, the agricultural science and technology system is undergoing reform. Based on natural conditions in Yunnan and the laws of the development of science and technology, it must gradually come to be a system with various points of focus and all kinds of characteristics, that will coordinate the developed provincial, prefectural, and county hierarchical agricultural scientific research and dissemination. Agricultural science and technology must put the science and technology of foodstuff production at the forefront, and cannot be lax in doing so. It must enthusiastically expand its horizons, and develop toward fitting the industries of agriculture, forestry, animal husbandry, by-products, and fishing with production, supply, sales, storage, shipping, and processing. And also, on the basis of experiments and demonstrations of mountain region development, to place mountain region development among the important items on the agenda, strengthen leadership, make reasonable arrangements, study and formulate development plans, and by relying on the broad mass of scientists, technicians, cadre, and the public, to put a new face on the comprehensive development of the mountain regions.

6. Fully develop the roles of current talent, and enthusiastically train various kinds of specialist talent. Implement a management system for scientists and technicians that integrates planned deployment with a hiring system. On an experimental basis, gradually expand the scope of the hiring system. We must maintain reasonable transfers of talent, must combine projects of technology development and economic cooperation, must adopt

various channels and modes, must develop intellectual support and intellectual movement, and must organize scientists and technicians who are in the field from central areas to make contributions to the economic construction of Yunnan. We will better implement the policy toward intellectuals, and will be concerned about them politically, vocationally, and in their living environment. We will integrate the characteristics of the intellectuals, will develop education regarding communist ideals and professional ethics, and will do well at building spiritual civilization. We will base ourselves upon training the various specialist talents in the province and at the local level, and will especially enhance the cultivation of specialist talent at the borders and in the mountainous regions. We have decided in the province that each year we will send a group of young and middle aged scientists, technicians, and teachers to study abroad and for advanced training.

7. As science and technology develops, science and technology legislation becomes more urgent. Based on arrangements by the national people's congress, scientific and technical circles and legal circles must make a concerted effort to study and propose local laws and regulations in the fields of science and technology to ensure the development of science and technology in this province.

Finally, the "Report" stressed that to strengthen the scientific and technical line and carry out a full scale restructuring of the science and technology system would be a major event in the whole picture of the modernization of Yunnan. All levels of leadership must take the lead in studying the "Resolution," in further improving understanding, in clarifying the goals, direction, focus, and policies of the restructuring of the science and technology system, in conscientiously augmenting leadership, and in carrying scientific and technical service in this province forward to a new stage of development.

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NATIONAL DEVELOPMENTS

PROVISIONS TO TIGHTEN S&T APPRAISAL SYSTEM DETAILED

Tianjin JISHU SHICHANGBAO [TECHNOLOGY MARKET WEEKLY] in Chinese 15 Oct 85 p 1

[Text] To enhance the management of scientific and technical achievements, and to put a stop to formalism in the appraisal of scientific and technical achievements, the State Science and Technology Commission and the State Economic Commission have jointly issued "A Circular Regarding Enhancing the Management of Scientific and Technical Achievements," subject to approval by the State Council. It was pointed out in the communication that the technical appraisal of scientific and technical achievements (including developmental achievements by enterprises with new products and new techniques) is an important link in science and technology. For some years now, many regions and departments have diligently implemented management rules for scientific and technical achievements, strictly carrying out the appraisal of scientific and technical achievements, which has stimulated the exchange, application, and dissemination of scientific and technical achievements. This has had a positive effect on stimulating progress in science and technology and for the development of economic construction. However, because the system has not been sufficiently perfected, there are too many scientific and technical appraisal conferences of all kinds. Whether an achievement is large or small, an appraisal conference is held for it, which happens throughout the country no less than hundreds of thousands of times each year. Many appraisal conferences are merely formalistic, which costs the workers financially, and some of the conferences have been changed from serious appraisal conferences to product marketing conferences. In carrying out appraisal of achievements, some units treat their guests royally and present gifts, take them on trips, and lower the appraisal standards at will, even to the extent that some immature scientific and technical achievements have entered society to the loss of the state, groups, and individuals. Therefore, the "Circular" has made five specific provisions.

1. That each area and each department must strengthen its leadership in managing scientific and technical achievements, must diligently carry out the "Provisional Regulations for the Technical Appraisal of New Products and New Techniques" passed by the State Council in 1961 and the "Provisions Regarding the Management of the Achievements of Scientific and Technical Research," passed in 1984 by the State Science and Technology Commission, scientific and technical achievements must be strictly appraised according to standards, and the level of scientific and technical achievements must be ensured.

2. That for the evaluation and appraisal of scientific and technical achievements, evaluation may be carried out differently under different conditions. Anything falling under the following conditions may be regarded as the conclusions of appraisal, for which another appraisal conference need not be held: (1) when based on the research tasking letter or contract there has been technical checking and testing for approval by the relevant specialist department given the task, and when certification has been issued; (2) when technical maturity has been demonstrated in actual production practice, when it is economically reasonable, when there has been a technical evaluation, when inspection by the relevant specialist department is up to standard, and when certification has been issued; (3) when inventions and creations have been issued patents by the China Patent Office, and after implementation have achieved economic results; (4) if the achievements of scientific theory have already been read before a national (or international) scholastic conference, or have been published in a national (or international) scholastic publication.

3. For appraisal conferences of scientific and technical achievements that must be held, the scale should not be excessive, arrangements should be streamlined, attention should be paid to particular results, and formalism should be avoided.

4. For the evaluation and appraisal of scientific and technical achievements, full preparations must be made beforehand according to the rules, and a technically responsible person will be appointed to be in charge of the evaluation and appraisal. Technically responsible people ought to assume a technical responsibility for the achievements that are appraised. There must be no fraud in the evaluation and appraisal, nor favoritism or irregularities, nor the treating of guests or the presentation of gifts, nor squandering without restraint: there may be no invitations to non-technical personnel who have no connection with the evaluation and appraisal. If any of the conditions mentioned above are discovered, it will be the responsibility of the relevant units and personnel.

5. In view of the fact that at present China's management of scientific and technical achievements and appraisal methods are still inadequate and imperfect, it is planned that on the basis of investigation and research we will work out relevant management methods that will be implemented after approval by the State Council.

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SCIENCE, TECHNOLOGY IN BORDER AREAS

Kunming YUNNAN RIBAO in Chinese 10 Oct 85 p 2

[Article by Sun Cuifang [1327 5050 5364]: "Passing On Science and Granting Technology Hastens the Economic Take-off on the Border"]

[Text] Since last year, the science and technology marketplace in our province has been like bamboo shoots after a spring rain in its abrupt development. According to incomplete statistics, more than 10 regions, prefectures, and municipalities throughout the province have held science and technology exchange conferences, have organized hundreds of science popularization fairs, have stimulated broad applications in science and technology, and have given impetus to economic construction at the border.

Opening up technology markets allows science and technology to flow into production as quickly as possible, it is a requirement of contemporary economic construction, and is the urgent wish of the vast majority. The science association of Mengzi County organized a two day science popularization fair, attended by as many as tens of thousands. More than 5,000 jin of improved varieties were sold, more than 8,000 scientific or technical problems were resolved, and more than 8,000 popular scientific books or materials were sold. The Honghe Zhou Scientific and Technical Achievements Trade Fair sponsored by the Honghe Hani-Yi Autonomous Prefecture Science Commission, the Gejiu City Science Commission, and the Yunnan Tin Company Science and Technology Department was held for 7 days in Gejiu City. Business was vigorous throughout. The new product of the Jianshui Sugar Refinery, "bagasse pulp board," resists rotting, insects, and rats, has a low rate of absorbency, has good nail holding and processing performance, can be sawn or planed, can be painted, and its strength is superior to particle board and ordinary fiberboard. It has gained a good reputation, and more than 50,000 yuan worth was sold at the fair. The Chuxiong Yi Autonomous Province held its first science and technology trade fair during Torch Days this year in which 25 units participated, where there were more than 400 items, 4 transactions were concluded in the first 3 days, and there were intentions to sign for 12 other items. The scientific and technical achievements trade fair held by Lijiang Prefecture took place during the traditional mule and horse exchange fair, where there was a crowd of more than 23,000, where the volume of business was more than 55,000 yuan, where more than 2,700 scientific or technical materials were sold or given away, and where more than 200 people

were helped with advice. In addition, there were intentions to buy 500,000 jin of red sugar, 500,000 jin of wheat varieties, and 10,000 Ximengde logs. The science and technology markets and science fairs held by the prefectures and counties of Qujing, Dali, Baoshan, Simao, and Jinning were spectacular beyond precedent, where tens of technical service units sprang up, every outfit putting out its sign, objects were spread out for display, graphs and pictures were hung up, and specialists and technicians sat around. With all the talking, questions, and laughing, they got to be called "streets where experience is passed on and treasures sold" by the masses.

The science and technology marketplaces are not only channels to get science and technology into production, but also provide opportunities for the exchange of experiences to town and township enterprises, urban and township individual households, and rural specialty households. The edible mushroom specialist householder of Chengguan Township in Mengzi County, Yin Yuekun [1438 6460 2492], displayed at a street fair the edible mushrooms that he had grown, where more than 10,000 people saw them, and many people contended with each other to buy them. The mature cut tobacco processed by specialist householder He Jiasheng [0149 1367 5116] had in the past been trial sold in an office, where it took a week to sell one package. By advertising at the Mengzi science fair, where there were people both looking and sampling, in two days he had sold 680 packages.

Now, science and technology fairs are a common sight everywhere in this province, not only in the county seats and the interior, but also along the borders in prefectures, villages, and collective townships. Some areas use market days, while others use holidays. The March holiday in Dali, the Torch Day of the Yi people, the Water Sprinkling Festival of the Dai, and the "Danao" (Zongge) Festival of the Jingpo nationality have all held science and technology fairs. When an area holds a science and technology fair, people come from all around. The tide that is the study of science and the use of science is rising higher and higher in our province.

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TECHNICAL SUCCESSES IN NINGXIA MOUNTAINS DESCRIBED

Yinchuan NINGXIA RIBAO in Chinese 22 Oct 85 p 1

[Article by Ma Ying [7456 3841] and Wu Kerang [0702 0344 6245]: "Scientists and Technicians From Units of Academia Sinica Have Had Notable Results in Supporting Construction in Mountainous Regions"]

[Text] In response to an invitation by the autonomous region party committee and government, and under the sponsorship of the autonomous region science and technology commission a "Conference for Scientists and Technicians Supporting Construction in the Mountainous Regions of Southern Ningxia" was held from 10 to 13 October in Yinchuan to confer about and exchange experiences in the support of construction in the mountainous regions of southern Ningxia.

During the meeting, Li Xuezhi [2621 1331 2535], autonomous region party secretary, and Ma Yingliang [7456 5391 0081], vice chairman of the autonomous region, called on scientists and technicians supporting construction in the mountainous regions of southern Ningxia to thank them and express their solicitude.

Units from the Northwest Water Conservancy Research Institute of the Chinese Academy of Sciences and the Forestry Sciences Institute of the Chinese Agricultural and Forestry Sciences Academy began sending scientists and technicians to support construction in the mountainous regions of southern Ningxia in 1980. All together, they erected 19 research and experimental stations in the southern mountains, and on the basis of surveys and research worked on 29 scientific experiments. At present, 27 have been appraised, and 17 have been awarded prizes as great scientific and technical achievements from both the autonomous region and the nation. When scientists and technicians from the Beijing College of Forestry were helping Xiji County in full scale development of afforestation and grass planting, they selected as an experimental site for comprehensive management of small drainage areas the Huangjia village of Ercha in Daping township as an area where conditions were the worst and where management was quite difficult. They carried out simultaneous planning, design, and engineering, came up with both biological measures and engineering measures, and after 3 years of struggle turned around the situation there of extreme deficiencies in the "three feeds." Per capita foodstuff production doubled and income tripled. At the same time, they had worked up a model for the southern mountainous regions to control runoff in

water conservation and to implement full scale, comprehensive management. Guan Junwei [7070 0689 5588], a more than 70 year-old professor, gave up the comforts of his later life and joined other scientists and technicians coming to the southern mountainous regions, and rushing back and forth over mountain bridges, made his contributions to the construction of the protective forest project in Xiji. More than 20 scientists and technicians from the Northwest Water Conservancy Research Institute of Academia Sinica developed scientific research work in 15 projects in the counties of Guyuan, Tongxin, and Pengyang. Their projects included comprehensive inspection of resources, protection of natural areas, extension of experiments with the introduction of Hongdou grass, experimental aerial sowing of shadawang, a high yield model for Yinnan pastures and crops, and fuel forest experiments. After 6 years of industrious cultivation, five of the projects were awarded prizes by the Autonomous Region as significant scientific and technical achievements, and the projects as a whole have quickly allowed science and technology to become forces of production. In a situation where plowing has been cut back, the land to be returned to forestry and grazing, food production at Shanghuang Village in Hechuan Township in Guyuan County has still increased annually. And large family livestock has gone from an original 24 head to the current 340. The area has become a model for comprehensive development for mountainous agriculture, forestry, and grazing. Scientists and technicians have helped the public plant 107,000 mu of fuel forest in Pengyang and Guyuan, where the same year that they plant they can receive the benefits, which has been welcomed by the public. Li Li [2621 4539], a middle aged assistant researcher, took up the research topics of shadawang aerial sowing experiments in arid semi-desert regions," "experiments and research into the introduction of Hongdou grass into mountainous regions in southern Ningxia," and "a loess plateau agricultural resource--fuel forest research" in the three counties of Tongxin, Pengyang, and Guyuan, respectively. For over 5 years she has had to overcome serious difficulties until August of this year, when under her supervision shadawang aerial sowing was finally successful at Xiamaguan in Tongxin County with rainfall of 250 mm, which after appraisal is considered to be the first time either in China or abroad. And at the same time, after 5 years of demonstration and dissemination with experiments and research into the introduction of Hongdou grass, more than 30,000 mu has been planted at present in the Guyuan and Yinnan areas, economic results from which have been more than 4 million yuan. The success of these two experiments have provided a scientific basis for recovering vegetation in the mountainous regions, for improving the ecological environment, for controlling water and soil loss, and for dealing well with the construction of grazing land base areas.

Autonomous Region Party Secretary, Li Xuezhi, gave a speech at the meeting. He said: "I represent the Autonomous Region Party Committee and the People's Government in extending our greetings to the scientific and technical workers who have supported construction in the mountainous regions of southern Ningxia, and I express our gratitude to those comrades who once worked here, as well as to the leaders of the units still here. You have worked long in the countryside, where transportation is inconvenient and life is difficult and arduous. However, having the loftiest ideals and having the spirit of serving the people, of serving socialist construction, and of sacrifice to communism, you have been able to overcome all difficulties. We should learn from this spirit of sacrifice that you have." He pointed out that changes in

the mountainous regions of southern Ningxia have been great over the last few years. Those changes have been the greatest in those areas where you have developed scientific experiments at the grassroots level, which shows that our work has already been very successful. However, the mountainous regions will not only change their natural appearance, but will also become wealthier, which will require long term, unfaltering efforts. We have already set out on the road to control poverty and achieve wealth, which is an inspiration to cadre and the public in the mountainous regions, which has given hope to the people, and which has strengthened our confidence. In the past, these have been barren hills and desolate mountains, but now they are green, which has been a turn for the better. To have achieved this has been due to the concern and support of the party Central Committee, it has been the result of our carrying out correct principles, policies, and great struggle by the people, but it cannot be divorced from your persistence in carrying out scientific experiments and in developing technical guidance. You have taken up as your own magnificent mission the helping of a people to solve its problems and the changing of the backward appearance of its mountain regions, and have wholeheartedly served the people, unashamedly being good scientists of the people educated under the party. This area will never forget the party nor you.

After Comrade Li Xuezhi had spoken to the conference of the spirit of the national conference of party delegates, he said: In implementing the spirit of the Central Committee conference, scientific and technical workers are facing a formidable and grand task. We hope that after you go back you will diligently study the documents of the conference to strive for scientific and technical advances, and to even better stimulate real action in economic construction in the mountain regions, and to thoroughly implement the spirit of the three Central Committee meetings. Finally, it was his hope that everyone would share their good thoughts, their good experiences, and their good spirit to achieve even greater victories for construction in the mountainous regions of southern Ningxia.

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LOCAL S&T ENDEAVOR IN ECONOMIC REFORM DISCUSSED

Beijing KEYAN GUANLI /SCIENCE RESEARCH MANAGEMENT/ in Chinese No 4, Oct 85 pp 40-42, 52

/Article by Zhang Penghui /1728 7720 5057//

/Text/ I. Total Implementation of New Policy on S&T Development

The new policy on science and technology /S&T/ development approved by the party Central Committee and the State Council is not only a guiding policy for S&T development but also one for the development of the national economy. The keywords for the five items in the policy are "rely" and "cater." In the past, it was believed that reliance was the business of the individual departments involved in the national economy and that the S&T Commission mainly catered to and serviced their needs. In fact, this kind of understanding is incomplete. We should pay attention to service on the one hand and to reliance on the other. If one paid attention only to service, one would never be freed from the passive nature of the S&T Commission in dealing with specific projects and would not be able to fulfill the functions of an integrated department and hence not be able to serve well the role of advisor and aide to the party committee and the government.

To implement fully the new policy on S&T development, we initially organized the "Science and Technology Year" activity throughout Henan in 1982 to sway public opinion so that leaders at all levels would pay attention to S&T, that the role and status of intellectuals in the four modernizations constructions would be promoted, and that the initiative of scientists and technicians would be brought into play. To advance S&T further, foundations were laid in 1983 on the basis of what was accomplished in the Science and Technology Year and in areas covering research organizations, research projects, and technical personnel. The year 1985 should be a fruitful year in producing results, talent, and expertise. Our guiding ideologies for the coming year include: paying attention to S&T management and reform, promoting greater integration of S&T with national economy, and fully exploiting technical personnel in order to enhance the role S&T advancements play in the development of the national economy and to promote the progress of the national economy.

From the perspective of individual organizations, individual areas, and individual fronts, whether the new policy on S&T development will be fully implemented, whether S&T will receive proper attention, and whether the S&T endeavor will produce results all depend on the following objective criteria and specific requirements:

a. The research projects chosen must be appropriate and short-term, with reasonable input-output ratios and economic results being constantly improved.

b. The propagation of scientific results and imported advanced technologies should be gradually expanded from the current 30 percent to over 40 or 50 percent in order to elevate society to an advanced level.

c. Among the factors in national economic development, the contributions of scientific achievements should be gradually increased by great efforts from the current 10 percent to 20-30 percent or even 50 percent.

d. More expertise and talent should be dedicated to scientific research and S&T management and their technical and managerial skills should be constantly improved.

e. The proportion of the national economy invested in scientific research should be gradually increased and attention should be paid to the groundwork for scientific research in order to improve the research environment and raise the capability and level of scientific research step by step.

Based on past experience and existing problems, efforts should be made in the following areas in order to implement better the new policy on S&T development and to improve S&T management:

1. Drawing the attention of the leaderships and winning the support of departments. Get out of the confinement of departmental work, get involved in central operations, and advance departmental work while working in central operations. To draw the attention of the leadership to S&T endeavors, one can present S&T accomplishments and summarize the representative examples of S&T-enhancing production and economic development to the leaders and point out existing problems in S&T endeavors and their solutions.

2. Making clear the guiding ideologies. Cater to the needs of the economy and society, encompass economic development, and change from simply paying attention to projects to paying attention to policies, planning, organization, management, and ranks so as to fulfill the functions of an integrated department.

3. Having one's feet firmly planted in the local area, keeping in view the whole nation and setting one's sights on the world. Center around local resources and technological advantages, pick the right targets,

organize coordinated efforts to tackle major projects, and develop premium products and superior industries so as to convert resources and technological advantages into products and industrial advantages; to adhere to combining technology with the economy and with trade, and to accomplish the goal of one developmental project, one specialized corporation, and one superior industry for each local resource.

4. Respecting knowledge, respecting talent, and bringing into full play the role of S&T personnel in the four modernizations constructions. Pay attention to introducing talent from other norms and abroad on the one hand and bringing into full play the role of scientific and technical personnel of one's own area, department, and organization on the other. While implementing the policy on intellectuals, whatever can be offered to outside talent should first be offered to local S&T personnel, because the situation of "winning a son-in-law but losing a son" is absolutely unacceptable. From now on, the focus of talent development should be on the middle-aged and young S&T personnel and not only academic credentials but also competency should be considered. Those with genuine talent and ability should be exploited and the middle-aged and young S&T personnel should be placed in essential positions so as to make the best possible use of manpower and provide an opportunity for it to exercise its abilities.

5. Reinforcing the progress of S&T commissions themselves, constantly improving their S&T management, and bringing into play the initiative of the S&T personnel of the commissions. To accomplish these, a job responsibility system can be set up to link one's performance with economic results.

II. Rural S&T Endeavor Should Accommodate the Trend of Further Deepening the Rural Economic Reform

Since the 3rd Plenary Session of the 11th Party Central Committee, great results have been accomplished in the rural economic reform of Henan and the rural economy has made significant progress. Currently, the new situation of rural reform is mainly manifested in the following areas:

1. After implementing the agricultural responsibility system, the initiative of peasants is brought into play. Year after year rich harvests of grains have been reaped, with a great jump in production. Aside from the grain for internal consumption, seed and animal feed commodity grain increases rapidly and causes problems in the sale, storage, processing, and transportation of grains and cotton. Without proper solutions, the incentive of peasants to produce will be dampened and the agricultural productions affected.

2. Along with the development of agriculture, fisheries, industrial sideline production, the processing industry, and the service industry have also grown significantly with the emergence of a large number of specialized households and S&T households. They are the symbol of the advancement of rural productivity and the goals of a socialist rural economy.

3. With the revitalization of the rural economy and the advancement of productivity, the existing labor organizations have become obsolete and it is natural that new forms of labor organization and a new labor force will emerge. A group of rural specialized households have moved to the urban areas to engage in business and open up factories to serve the needs of urban production and life. In the rural areas, there have also appeared various specialized-technology development companies such as seed companies, plant protection services, fertilizer suppliers, and farm machinery companies. Under the circumstances, peasants have made new demands on S&T endeavors. If we satisfy its needs, the rural economy will make progress; otherwise the progress will be hampered. The peasant's demands are as follows:

1. Demand for better education and more scientific knowledge. More and more peasants realize that education determines their income and that S&T generate profits.

A survey of the Guoji administrative village of Fengtang Township, Yang County, fully demonstrates the relationship of income with educational level.

Of the 198 people in the village, the average per-capita income was 383.70 yuan in 1983.

Among them, eight families with a high school education have an average per-capita income of 509.5 yuan.

Thirteen families with a junior school education have an average per-capita income of 393.6 yuan.

Twelve families with an elementary school education have an average per-capita income of 303.9 yuan.

Seven illiterate families have an average per-capita income of 279.3 yuan.

2. Demand for a prompt supply of accurate S&T and product information. The accuracy and promptness of the information decide whether the undertaking will be a success or failure, or make a profit or lose money. Examples are abundant.

3. Demand for supply of scientific research results and qualified scientists and technicians. In certain cases, often a single breakthrough revives a factory and one able man controls the fate of an enterprise. One good example is the Nanyang Spoke Factory. By adopting a new chromium-plating technology, it has greatly improved the quality of its spokes and quickly occupied a large share of the domestic market.

In order to accommodate the trend of further deepening the rural economic reform and to satisfy the above-mentioned demands, attentions should be paid to the following rural S&T endeavors:

1. Establishing new guiding ideologies for developing rural economy. The traditional, self-sufficient style agriculture of the past works no longer. The new guiding ideologies should be: diversified operations, benign cycles, consolidation of agriculture, industry and commerce, comprehensive utilization, extensive processing, increase of commodity production, and stimulation of the rural economy.

2. Carrying out the strategic study for rural economic development. Make clear the correct direction, route, and policy for rural economic development; make good on long-range development planning; and methodically develop the rural commodity economy based on local resources.

3. Strongly supporting the growth, expansion, and development of the rural specialized households, S&T households, and all kinds of specialized-technology development companies.

4. Fully exploiting rural S&T personnel and skilled craftsmen to enhance the advancement of rural technology and the growth of production.

5. Strengthening the general and technical education as well as the propagation of the popular sciences in the rural areas to continue raising the scientific, cultural, and technical level of the peasant masses, particularly young peasants. Those young peasants who are technically distinguished can be trained at colleges. Effective measures should be adopted to eliminate illiteracy and to solve the problem of admitting school-age children as part of the great effort to cultivate the intelligence of peasants.

6. Giving attention and support to the consolidated planning and construction of new socialist villages and towns and handling well the rural commodity production bases and the technical market.

III. Urban Economic Reform Should Enhance the Technical Advancement of Enterprises

The major goals of enterprise reform were pointed out in the decision on urban economic reform approved in the 3rd Plenary Session of the 11th Party Central Committee, i.e., first, to modify the situation of redundancy and poor coordination and to lessen bureaucracy and control in order to extend the autonomy and to enhance the vitality of enterprises and, second, to adjust the relationship between the individual and the state and to bring into play the initiative of its employees in order to advance commodity production. Under the circumstances, the technical advancement of enterprises becomes particularly important. Therefore, the urban economic reform should enhance the technical advancement of enterprises.

1. Make clear and handle properly the relationship with all sides. Economic reform provides momentum, technical advancement gives vitality, and the economic result is the goal. The economic result mentioned not

only means a profit but should also include variety, quantity, cost, labor productivity, and technical advancement.

2. Adhere to one combination and rely on three kinds of technical forces. At present, there is an acute shortage of technically competent personnel in the frontline of production, particularly for the small and medium-size enterprises. In training people and advancing the urban economy one must adhere to the combination of labor and technology, that is, to win by intelligence and skill and rely on three kinds of technical forces, namely technical personnel, technical workers, and skilled craftsmen. Technical personnel refer to those technical personnel with a college or higher education. They have a sound basic training and are able to take charge of totally technical matters and to assume the leadership in enterprises. Technical workers refer to those middle-aged and young workers with a junior high school or higher education. They have engaged in technical work for an extended period of time, are familiar with the technical matters of their own specialties, and have experience at the basic level. They can be appointed section chiefs, workshop directors, production unit chiefs, and deputy factory directors for production. Skilled craftsmen refer to those with little education but with ample production experience. They have become very good at certain key production techniques and can remedy any problem. They can be organized to participate in technological transformation and technical projects that will advance technology.

3. Emphasize the advancement of technology. The promotion and utilization of scientific achievements and the digestion and absorption of imported advanced technologies should be the breakthrough for the S&T management reform. The cost of technology transfer should not be too tightly controlled and there is no need for a centralized regulation.

4. Focus on product renewal, technology renovation, and managerial improvement. Handle well product design. technical design, equipment design, and production facility planning. Errors in design can cause tremendous waste or cannot even be corrected. Only by constantly improving product design can product renewal be sped up and competitiveness improved.

5. Technical and economic policies should be conducive to the advancement of technology and the growth of production. The policies should define their scope with a certain degree of flexibility. For example, how to support new products, how to set higher prices for better products, how to accrue funds for the technological transformation of enterprises, and how to limit the production of overstocked products should all be specified in these policies.

6. Handle well the construction of scientific research means and bases (such as a new product analysis lab, technical research lab, and product durability testing lab) and pay attention to the application of computers in industrial process automation and business management. Set up various

kinds of new-technology development companies on a trial basis and ensure those specialized companies are geared toward the society and serve the needs of all trades and professions. Those specialized companies should be supervised directly from design and material acquisition all the way to construction and test runs.

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NATIONAL DEVELOPMENTS

IMPACT OF TECHNOLOGY MARKETS SURVEYED

Beijing ZHONGGUO XIANGZHEN QIYE BAO 2 Nov 85 p 2

[Text] The Chinese International Information Center

This center is an independently accounted joint information and service organization that is composed of more than 30 ministries, commissions, and specialist information research institutes under the State Council, the Beijing Municipal Information Research Institute, and relevant research and design units.

The primary range of services for this center include: to provide for regional economic exploitation and professional technology exploitation information and research reports of a policy making nature; to provide an information service for the capital, special economic zones, open cities on the coast, and frontier regions; to provide an economic and market information service for the importation of foreign new technologies, new sample products, and new equipment; to provide information and technical service for the technical transformation and technology exploitation of small to medium enterprises and town and township enterprises; to provide an information service for the transfer of rights to achievements by scientific research units and scientists and technicians, and to act as a go between for their dissemination; the administration office for the center is at No 74 Dengshikou Dajie in Beijing.

The Fuzhou Technology Market

The permanent Fuzhou Technology Market was officially opened for business on 20 May at the southeast side of the Wu Yi public square. This market was held jointly by the Fujian Provincial Science and Technology Commission, the Provincial Government Office of Economic Cooperation, and by the Fuzhou Municipal Science and Technology Commission. They have entrusted the specific operation to the Fuzhou Center for Exploitation and Exchange of Science, Technology, and Personnel.

The operational scope of the market: to introduce new technology, new techniques, new materials, new products, both foreign and domestic, and to import and transfer the rights to technical achievements for the comprehensive utilization of local resources and management of the "three wastes"; to introduce the transfer of rights to technical breakthroughs and technically

innovative achievements that will effectively reduce production costs, that will save energy, and that will improve product quality; to resolve technical difficulties in production for urban and township enterprises, to spread the grand technical restructuring, and to guide the absorption of imported technology.

Shanghai Is the First Technology Market to Open to the Outside

This market is placed in the west auditorium of the Shanghai Gymnasium, occupying 300 sq m. Units from more than 100 organizations in systems such as the Municipal Science and Technology Commission, the Economic Commission, the Shanghai Academy of Science, the higher institutions, defense industry offices, and troops provided more than 600 items, which were the first "commodities" in the permanent technology market. No entrance fees were requested for the fair and there were no rental fees, which allowed both sides to trade freely and to make deals.

Jiangxi Has Begun Technology Fairs

Technology markets are just beginning in Jiangxi. At present, 70 counties (or prefectures) have begun technology fairs. The technology markets of Jiangxi began testing in April of last year, where the technology markets in each area launched technical service activities, chief among which are the following: 1. spread advanced technology and help the public open doors to wealth; 2. develop technical consulting services, compensated science popularization services, and technical training services; 3. carry out compensated transfer of the rights to technology and technical contracts; 4. compensated assembling of talent and organizing compensated technical guidance contingents.

Shenyang Municipality Technology Markets Develop a Positive Function

Since the Shenyang Municipal technology markets began in 1980, they have been a positive influence.

1. They have stimulated the transfer of technical achievements into production, and they have encouraged the technical advancement of enterprises. In recent years there have been 11,264 contracts for the transfer of technology. Based on a survey of the more than 1,500 technology contracts already completed, more than 700 million yuan in profits has been realized.

2. They have advanced the restructuring of the science and technology system. Technology commercialization has changed the situation where in the past science and technology units "depended upon upper echelons for expenses, where tasking was passed from above to below, and where achievements were reported to the upper levels."

3. They have stimulated the transfer of military industrial technology to civilian use. In 4 years military industry units have concluded 2,049 contracts with Shenyang civilian enterprises to transfer the rights to technology, which has already become the mainstay of the Shenyang technology market.

4. They have stimulated improvement in the standards of teaching and scientific research. One quarter of the technology contracts taken on by Dongbei Engineering Academy have been selected as topics to train graduate students. One teacher on the staff of this institution trained five graduate students with the subject he had accepted, and cooperated with his comrades to write three textbooks.

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METALLURGY INSTITUTE GEARS UP FOR S&T DEVELOPMENT

Shanghai JIEFANG RIBAO in Chinese 8 Nov 85 p 1

/Text/ The Shanghai Metallurgy Institute of the Chinese Academy of Sciences has geared itself for the economic construction, adhered to reform, and actively and selectively engaged in S&T development. In recent years, S&T development projects of the institute cover a territory stretching from the three northeastern provinces in the north to the Shenzhen Special Economic Zone in the south with collaborating organizations scattered about some 50 locations within 18 provinces and municipalities. An economic benefit of 170 million yuan has been produced for the society.

Reform has generated a refreshing vitality for the institute and has changed the traditional, biased view that scientific researchers who undertake applied research are inferior. Researchers have moved into social studies and surveys and now realize the importance of bringing the strengths and advantageous conditions of the institute into full play. Through the establishment of lateral contacts with the departments dealing with the national economy, 17 projects that are technically feasible and have a key importance were initially chosen. By means of promoting scientific achievements, technology transfers, consulting services, and the establishment of cooperatives, it has opened up a new situation for development.

In order to strengthen lateral contacts and coordination, the Shanghai Research Center for Metal Corrosion and Protection Technology, the Metallurgy Institute being its pivot, was established with the approval of the municipal S&T commission. The bigger projects accepted so far include the anticorrosion work on the diversion pipeline for the Huangpu Jiang. The original plan specified that the diversion pipeline last for 60 years. After further study, it was concluded that the useful life of these pipelines can be extended to 80-100 years with pipeline protection measures. Through arrangements such as technology sharing and financial investments, the Shanghai Metallurgy Institute has formed joint research and production enterprises with local organizations. The institute has formed a joint venture for producing specially shaped aluminum alloy materials with Tai County, Jiangsu. Phase one of the construction is completed and is in the process of being tested. The estimated production output is 10 million yuan. In the area of developing magnetic materials, the institute has formed a production co-op with Wu county, Jiangsu. The business started production in September.

For those research projects that will produce big economic results, are technology-intensive, and are difficult for local enterprises to undertake, the institute carries out the batch processes through its newly formed pilot-scale development diversion in order to develop some successful products for the institute.

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NATIONAL DEVELOPMENTS

S&T AWARDS CEREMONY HELD

Kunming YUNNAN RIBAO in Chinese 10 Nov 85 p 1

/Text/ The 1984 Yunnan S&T achievement awards ceremony was held at Kunming's Science and Technology Building on 9 November 1985 and 183 instances of excellent S&T results were awarded, in which 136 were basic research results and 47 were promotion results.

Among them, 2 items won first rank awards, 16 second rank, 66 third rank, and 99 fourth rank. These awarded achievements are the careful choices of the provincial S&T advancement award evaluation committee. The majority of them are of a higher academic level, some are at the forefront at home, and some are advanced by international standards. A substantial number of the results are new items developed by utilizing the resource advantages of theprovince and are readily applicable. They have played significant roles in the economic construction and social development of the province.

At the ceremony, Liu Zhibin /0491 2535 2430/, chairman of the evaluation committee, reported on some issues concerning the 1984 S&T results evaluation. He commented that to give correct evaluations to S&T results and to award the S&T workers and S&T management personnel who made contributions is to show the party's and government's concerns for S&T and their expectations of S&T workers. S&T workers should remember well the trust of the party, make great efforts to climb to new heights in science, and create more advanced S&T results in order to make great contributions to the progress on this province's economy and to China's socialist modernization. Zhang Jiaoluo /1728 2043 5012/, director of the provincial S&T commission, was present to congratulate the award winners.

Comrades in charge of S&T works at all provincial committees, offices, and bureaus as well as colleges and universities, comrades in charge of S&T commissions in every city and prefecture, and members of the provincial S&T advancement award evaluation committee--over 300 people altogether--attended the ceremony.

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list in an effort to carry out the task of promotion and application. This region attended the first national technical trade meeting and made exchanges worth over 5 million yuan. At the advanced industrial technology exchange meeting of the five northwestern provinces and regions which was held in this region, we made technical trades that amount to over 10 million yuan. These technical results flow into enterprises and villages where they are converted into products. According to the survey of the four institutes (architectural engineering, light industry, chemical engineering, and mechanical engineering), their technology-generated revenues for the first half of the year are several times more than those of all of last year. The Ningxia Architectural Engineering Institute is close to self-supporting.

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NATIONAL DEVELOPMENTS

TIANJIN'S SCIENTIFIC ACHIEVEMENTS DURING 6TH 5-YEAR PLAN

Tianjin TIANJIN RIBAO in Chinese 12 Nov 85 p 1

[Article by She Dede [0152 0344 1795]: "Tianjin's Bumper Crop of Scientific Achievements during the 'Sixth 5-Year Plan'"]

[Text] Tianjin harvested a bumber crop of scientific achievements during the "Sixth 5-Year Plan" because it has firmly oriented science and technology toward economic construction.

Statistically, from 1981 through September this year, over 1,000 achievements from the municipality won national and municipal awards, including 35 which obta.ned national invention awards. At the 13th International Invention Exhibition in Geneva in 1985, 4 projects from Tainjin won 5 awards, including two gold medals, one Asian grand prize, one gold-plated medal and one silver medal. In addition, 40 Tianjin projects won the recently announced national scientific and technological advancement prizes.

An outstanding feature of these award-winning achievements is that the vast majority of them have obvious social and economic results. An analysis of 129 achievements which were candidates for this year's national scientific and technological advancement award shows that 99 have increased economic results for the state by 800 million yuan. "The technology of vacuum industion overlay welding of exhaust valve in internal combusion engines," which won the National Invention Prize, Class 3, uses 60 percent less alloy compound metal than the world's most advanced welding technology and is at least 6 times more productive than the most advanced technology at home. It has been widely adopted in a dozen factories in China so far, its contributions to economic results about 5 million yuan annually.

The modernization of the technology and products of old enterprises and the improvement of their productivity have been accelerated considerably by the application of a host of scientific research achievements which require little capital but produce quick results. After their adoption in the city and the rest of the nation, such new materials or processes as XZ-revolving thin-film evaporator, ground covering technology, new permanent-magnetic materials, nitriding titanium imitation-gold coating, artificial incubation of white crucian carp, artificial matching of bait for prawn, and new green fodder and corn varieties have all produced outstanding economic results.

Tianjin has also laid a fairly solid scientific foundation in such up-and-coming technologies as microcomputer technology and software, optical communications, laser technology, biotechnology and new materials. If only we work hard to create the right conditions, we can expect to create certain new industries in the "Seventh 5-Year Plan" period.

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NATIONAL DEVELOPMENTS

ECONOMIC, TECHNICAL COOPERATION BETWEEN PRC, EEC

Beijing GUANGMING RIBAO in Chinese 19 Nov 85 p 1

[Article by Wu Fengzhou [0702 6646 0719]: "Economic and Technological Cooperation Between China and the EEC Continues to Develop"]

[Text] This is the 10th anniversary of the establishment of relations between China and the EEC. Since the establishment of relations, joint efforts by both sides has led to continual development of relations between China and the EEC.

Since China began to implement open door policy in 1979, China has developed economic and technical cooperation relationships with many nations on the basis of the principle of equality and mutual benefit. China is working gradually to perfect its legal regulations for economic ties with foreign countries, guarantee the legal rights and interests of the holders of technology, and provide excellent environmental conditions for foreign businessmen for investments and technical transfers. The efforts we have made in this area have received praise and support from the related countries' governments, and from business and financial circles. During these few years, the economic and technical cooperation relationships between China and the EEC have expanded continually. Of the foreign economic trade contracts for technical imports that were examined and approved in the 4-year period from 1981 to 1985, import contracts with the nations of the EEC totaled $1.8 billion. In the 9 months of 1985 alone, there were 168 contracts worth more than $1.1 billion. There has been a substantial increase in the number of contracts and amounts involved in contracts signed between China and the Federal Republic of Germany, and it leapt from third to first place in proportion of technical imports to China. More than four times as many contracts were signed with France in 1985 than in 1984, and the number of contracts signed with Italy and England have more than doubled in comparison with the same period in 1984. There also have been substantial increases in the number of contracts and amounts involved in contracts signed with other EEC nations.

To achieve better organization of EEC projects, we must not miss an opportunity to develop work with the outside. In 1985, the Ministry of Foreign Relations and Trade made four visits to nations of the EEC and received warm welcomes from the governments and business circles of these countries. We feel that the size of a nation or an enterprise is not important. The main thing is that they

must have advanced technologies that meet China's needs, in which case we all are willing to adopt various forms of cooperation. China has more than 400,000 enterprises, most of them medium and small enterprises. Most of the enterprises need to carry out technical transformation and will need to build a substantial number of new capital construction projects in the future. The range of cooperation with the EEC is extremely vast.

With adherence to the principle of equality and mutual benefit, relationships of economic and technical cooperation between China and the EEC will continue to expand.

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NATIONAL DEVELOPMENTS

S&T LEGISLATION DISCUSSED

Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 25 Nov 85 p 2

/Text/ Along with the advancement of the reform of China's economic system and its S&T system, the strengthening of legislation in the S&T area has appeared more and more frequently on the agendas of important meetings. Marxist laws consider the formulation and exercise of laws and regulations the basic form of governing a state. There is no doubt that they are also an important measure for causing S&T to flourish and enhancing the coordinated development and close integration of S&T and economic construction. To hasten the pace of China's S&T modernization construction, a task of top priority is to strengthen S&T legislation.

S&T Legislation refers to the drafting, promulgation, and revision of S&T laws and regulations. There is no consensus at home or abroad as to what constitutes an S&T law. It is generally held that it is the collection of laws and regulations governing all kinds of social relationships in S&T activities. The matters to be governed include not only the overall S&T decision-making, forecasting, and planning but also detailed S&T research, development, and management. They further include the relationship between overall and detailed S&T activities. In human history, the emergence of S&T laws is not a random, accidental occurrence. Rather it is the result of the great advancement of modern S&T. Because S&T have become the enormous assets of modern society, the development of a social economy depends more and more on the progress of S&T. The new technological revolution is changing the social relationships formed in the people's social production activity and social life. Therefore, only by applying the laws that reflect the nation's S&T development, i.e., "positive, definitive, and universal regulations," to handle properly relationships among the state, collective, and individual, the relationship between man and nature and relationships among different areas of S&T in S&T undertakings can the advancement of S&T be greatly enhanced, their social functions in social production and social life by fulfilled, and they become truly the cornerstones in raising social productivity. Simply for these reasons, the legislation of many countries since the end of World War II, especially from the 1970's to the present, is no longer focused on politics as it used to be. Rather it has been shifted to the areas of S&T and the economy. This is the challenge to traditional laws by S&T, or rather the "merger" of science and law.

The formulation of S&T laws and regulations can be traced back to the Yanan era in China's revolutionary history. During that period, the Chinese Soviet government issued about eight laws and regulations such as the "Measures for Rewarding Production Technology" and "Regulations on Remuneration for Cultural and Technical Cadres" that played positive roles in the consolidation and expansion of the red base. Over 10 regulations including "Provisional Regulations for the Protection of Invention and Patent Rights" were also formulated right after Liberation. However, like the whole socialist legal system of China, S&T legislation suffered a serious setback during the 10-year catastrophe of the "Great Cultural Revolution." It was not until the 3rd Plenary Session of the 11th Party Central Committee that S&T legislation made new strides along with the development of the economic system and S&T system reform. Nevertheless, legal construction in the S&T area has a long way to go when the requirements of S&T modernization construction and the objective needs of S&T system reform are considered.

Today we are carrying out legal construction in the S&T area under the circumstances of the reform. Therefore, it bears special significance. Just as many comrades pointed out at the recently held national symposium on S&T legislation, there was a "change of laws" accompanying every reform in history. Reform requires legislation and legislation enhances reform. At present, the party and state have formulated the strategy and policy that "economic construction must rely on S&T and S&T must be geared toward economic construction." Also a series of important and correct policies were made in the "Decisions on S&T System Reform by the Central Committee of the CPC." In carrying out the reform, millions of people have gained abundant experience. The tasks of S&T legislation are to solidify, put in clauses, and standardize in a timely fashion the national policies on S&T development and the successful experience of the masses in carrying out the reform so that they are transformed into rules of action whose enforcement is guaranteed by the power of the state and by which the results of the reform can be consolidated and expanded in order to realize a series of strategic goals and policies of the party and state for S&T development. Just as the teacher of revolution, Lenin, said: "If it is the will of the state, it should be expressed in the laws formulated by the organs of political power. Otherwise, the word 'will' is a meaningless sound." Consultations with both experts and the masses are required in studying what S&T regulations ought to be formulated. We believe that S&T regulations should be a relatively independent and integrated branch of the socialist legal system and that S&T legislation ought to cover the major areas as follows:

(1) Formulation of laws and regulations on S&T administration that specify the system and principles of state and local S&T management and the responsibility, authority, and personnel selection and appointment system of the administrative organizations at all levels.

(2) Formulation of laws and regulations on S&T planning that clearly define the principles, approach, content, management system, and hiring schedule in S&T development planning and the execution, examination, and supervision as well as reward and punishment system of the plan.

(3) Formulation of S&T civil laws that govern the property relationships and the personal non-property relationships including the right to inventions, discoveries, and S&T results of legal persons and citizens in S&T activities.

(4) Formulation of S&T labor laws that guarantee the right and freedom of citizens to engage in intellectual exercise and specify the wage, allowance, vacation, advanced study, labor protection, and reward and punishment systems of S&T workers.

(5) Formulation of laws and regulations on S&T to establish a system that deals with the exploitation and utilization of natural resources, the distribution and usage of facilities and equipment, and the management of information, literature, and files.

(6) Formulation of laws and regulations on financing S&T to establish allocation, loan, budgeting and final accounting, tax, and risk investment systems in the state's support of scientific research and technology development.

(7) Formulation of laws and regulations on S&T promotion to enhance the research, development, and propagation of those advanced and applied technologies of great significance by legal measures.

(8) Formulation of laws and regulations on S&T that involve foreign affairs to solve a series of legal problems that will emerge in the process of implementing the open-door policy, developing the import-export trade of technology, and carrying out international S&T cooperation. Naturally, S&T legislation is a tremendous task to perfect China's socialist upper structure and is absolutely not something that is done with a stroke of the pen. It needs the total cooperation and long-term efforts of S&T, economic, and legal circles. This year the State S&T Commission and related departments have engaged in the formulation of a technical contract law and are actively studying the formulation of research institute laws, S&T labor laws, regulations on mass organizations in natural sciences, and technology import-export laws as well as several ordinances, stipulations, and measures for supporting the S&T system reform. This is a good start. We believe that along with the perfection of the legal construction in the S&T area, China's S&T modernization will move forward at a faster pace and a new situation will emerge in China's socialist legal system.

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NATIONAL DEVELOPMENTS

PATENT APPLICATION RECEIPTS DISCUSSED

Beijing GUANGMING RIBAO in Chinese 29 Nov 85 p 1

[Article: "China Has Received More Than 12,000 Patent Applications, Two-Thirds of Them From Inside China and One-Third From Foreign Countries, Which Worldwide Is Considered To Be the Optimum Structure"]

[Text] Deputy director An Yutao [1344 3768 3447] of the Chinese Patent Bureau stated at the National Technical Progress Work Conference on 25 November 1985 that China's recently-born patent system has great vitality and may make a contribution to technical progress, improvement of economic results in enterprises and implementation of policies concerning intellectuals in China. According to statistics from the Chinese Patent Bureau, the bureau had received 12,649 domestic and foreign patent applications in the three categories of inventions, new uses and exterior design by 23 November. Two-thirds of them came from within China and one-third from foreign countries. This is considered to be the optimum structure worldwide.

According to our understanding, China will have received an estimated 14,000 patent applications by the end of 1985, ninth or eight place worldwide.

The interesting thing is that patent rights for many inventions and innovations have been transferred immediately after the applications are submitted, and some of them even have provided quite considerable economic benefits. Advanced engineer Yan Mengqiu [7346 1322 4428], director of the Shaping Energy Conservation Equipment Plant in Shaping Township, Changsha County, Hunan Province, has submitted a total of four patent applications to the Chinese Patent Bureau for an "oil burner for industrial boilers," a "diesel burner for industrial boilers" and other devices. After examination and approval for meeting specifications by the Patent Bureau, they were announced publicly inside China and abroad on 10 September. His inventions now have been extended to more than 80 factories. The Changsha Dyestuff Plant spent 4,000 yuan to install a diesel burner for industrial boilers before the announcement. It greatly increased product quality, reduced environmental pollution and conserved work time, and it resulted in a 56.2 percent fuel savings and provided more than 400,000 yuan in benefits within only 5 months. After using two oil burners for industrial boilers that burn heavy oil, the Benxi [Liaoning] Iron and Steel Company's Rolling Mill rapidly achieved high quality production and the average oil savings was 36.3 percent.

Industrial boilers in China burn about 40 million tons of crude oil and heavy oil and about 2 million tons of diesel each year. If Yan Mengqiu's invention were extended universally, we could conserve about 6 to 8 million tons of crude oil, heavy oil and diesel each year and create about 1 billion yuan in value. In addition, Yan Mengqiu could receive very subtantial royalties for the transfer of patented technology. According to statistics from the Hunan Patent Bureau, more than 90 inventions and innovations have been put into actual use in the province, and they may provide the state with more than 34 million yuan in taxes, and provide the patent transferrer with more than 3.8 million yuan in benefits.

In Beijing Municipality, the Beijing Patent Office alone has acted as an agent in the signing of 16 patent transfer contracts during the first 7 months of 1985 that will provide the state with an additional 40 million-plus yuan in benefits and the inventors with more than 2 million yuan in royalties for the transfer of technical patents. Some items already have attracted the interest of foreign businessmen.

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NATIONAL DEVELOPMENTS

SHENZHEN SEZ SCIENTIFIC RESEARCH WORK DEVELOPS QUICKLY

Beijing GUANGMING RIBAO in Chinese 30 Nov 85 p 1

[Article: "Scientific Research Activities Have Developed Rapidly in the Shenzhen Economic Zone—Import From Abroad and Transfer Within, Strive to Develop Scientific Research and Product Development"]

[Text] Since its creation, the Shenzhen Special Economic Zone [SEZ] has been active in linking up with advanced forces in the interior and importing advanced technologies from abroad in a major effort to develop scientific research and product development. Up to the present time, the SEZ has completed many S&T projects with rather high economic benefits, including 36 projects that received Shenzhen City superior S&T achievement awards. This was the situation outlined by Shenzhen CPC Committee Secretary Liang Xiang [2733 3276] at the First Shenzhen S&T Work Conference that opened on 27 November.

Liang Xiang said that before the SEZ was established, Shenzhen had only 27 technical personnel whose primary duties involved the application of technology in agriculture, forestry, animal husbandry and fisheries. They lacked basic scientific research and experiment measures. In the years since the SEZ was founded, the number of specialized scientific research organizations in Shenzhen municipality has grown to 12, and there are 8 enterprise technical development organizations and 15,000 S&T personnel of various types, including 8,300 with college or higher educational levels, more than 80 with advanced job titles and more than 2,300 with middle level job titles. In addition, there are large numbers of S&T personnel working in joint investments with concerned departments at various levels and assigned to units in Shenzhen. Liang Xiang said that this is the most solid force both for achieving rapid development of scientific research in the SEZ and for taking a major step toward the "technology window."

Administrative expenditures and equipment used for scientific research in the Shenzhen SEZ have increased every year. Administrative expenditures for scientific research in 1985 equalled the sum total for the previous 3 years and were 25.6 times as much as before the SEZ was established. There have been substantial increases in scientific research and testing measures, instruments and equipment.

Many enterprises and scientific research units in the Shenzhen SEZ have focused on cooperation with the interior for establishment of associations that integrate scientific research, education and production. This has been effective in

promoting technology imports and in testing and development of new products and new technologies. Examples include four items of "dual-concentrated" technology and equipment imported by the former Shenzhen City S&T Development Company, the SDH-A Chinese character generator developed successfully by the Shenzhen Electronics Research Institute, a flat fluorescent display and components and a high brilliance color super-large screen flat display tube developed by the Fenghua Electronics Industry Trade Company, and they have applied to the state in 1985 for three patents including one for a matrix fluorescent display. The Shekou Huanqiu [Global] Electric Machinery Company has developed electric machinery at international levels, and all their products are being exported.

In the area of linkages established with S&T forces in the interior, Shenzhen has concentrated on importing foreign advanced technologies and equipment. During the first half of 1985, the city imported more than 30,000 pieces (sets) of various types of instruments and equipment including a digital program controlled information exchange system and electroplating additive technologies from the United States, color television production lines and magnetic recording production lines from Japan, four-color closed and open printing machinery and airflow spinning and weaving technologies from West Germany, universal gate digital computer switchboards from Sweden, laser sightsinging technologies from Holland, oil paint production lines from Denmark, hollow core glass technologies from Austria and so on, and all of them are at advanced international levels.

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NATIONAL DEVELOPMENTS

ADJUSTMENT OF INTERNAL RELATIONS OF SCIENTIFIC PERSONNEL

Beijing GUANGMING RIBAO in Chinese 10 Dec 85 p 2

[Article by Zheng Haining [6774 3189 1337] and Wang Shaoding [3769 1421 0002]: "Adjusting the Internal Relations of the Scientific and Technical Contingent"]

[Text] In a recent interview with reporters, Zhou Guangzhao [0719 0342 0664], vice president of the Chinese Academy of Sciences, emphasized that the nation has a high-caliber scientific and technical contingent comprising hard-working personnel who are steeped in party education and love socialism fervently. We must have complete trust in them and rely on them. We must unleash their enthusiasm with policies and adjust the internal relations of the contingent so that every person can do what he does best. We must encourage them to contribute to the common objective--the promotion of economic construction and the development of China's science and technology."

Zhou Guangzhao said, "Based on the party's science and technology policies, the Chinese Academy of Sciences is currently mobilizing its subordinate research institutes to integrate their own work with economic construction. Some research institutes and offices must actively cooperate with enterprises and localities to organize developmental research or to stress such research in their applications in order to speed up the conversion of scientific research achievements into productive forces. For this reason, we must select some scientific and technical personnel and train them in business and management so that they can handle developmental work. We must correct the mistaken notion that only people unfit for scientific research will go in for development."

Zhou Guangzhao said, "A majority fo the scientific research projects at the Chinese Academy of Sciences are applied research. These projects are essential to the development of the national economy and must be accomplished." He emphasized, "The Chinese Academy of Sciences absolutely must not slacken its effort in long-term scientific research, i.e., basic research which will influence the national economy and social development beyond the 1980's. In accordance with the spirit of the resolution of the CPC Central Committee on the restructuring of the scientific and technological system, we must continue this kind of basic research in a steady, sustained way. We must prevent topic proliferation and overlapping. Selected projects which have great significance must be given the necessary conditions and qualified personnel

to ensure that the research bears fruit as soon as possible. We must ensure funds for basic research, applied research and other major research tasks of the state. We must also ensure a stable livelihood for scientific and technical personnel involved so that they can devote themselves to research wholeheartedly. We must do a good job in every type of work--scientific research support services, organizational management and social service work. We must correctly evaluate all kinds of labor."

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NATIONAL DEVELOPMENTS

INTEGRATED RESEARCH-PRODUCTION ORGANIZATIONS

Beijing GUANGMING RIBAO in Chinese 13 Dec 85 p 1

[Article: "China Now Has Nearly 10,000 Scientific Research and Production Associations--The Scope of Integration Continues To Expand, the Content Is Becoming Broader Day by Day, Various Forms of Integration Are Providing Advantages, Speed, and Benefits and Effectively Promoting Economic Construction"]

[Text] Emerging technical and economic organizations--scientific research and production associations--have undergone vigorous development in China in recent years. To date, an estimated nearly 10,000 associations of various forms have been set up in China. The scope of integration is expanding continuously, the content of integration continues to grow day by day and the integration has assumed a variety of forms.

Further intensification of reforms in S&T systems in China has been accompanied by the establishment of associations in most provinces, cities and autonomous regions across the country. Several trial points in Dalian, Shanghai, Beijing and other places have developed into actual implementation. The scope of associations extends through industry, agriculture, medicine, urban construction, environmental protection, communications, energy resources and other realms. The content of the integration has developed from technical transfers and development of new products to technical transformation within an enterprise, important topics within an industry and comprehensive technical and economic development within a region.

The associations come in many forms, and the overall tendency has been development from low to high levels:

They have developed from single-item technical cooperation to contractual responsibility to integrate an entire process. The contractual responsibility companies have integrated design, manufacture, construction, installation and other units to unify their pace and coordinate tacit understandings, which has shortened construction schedules considerably. The Shanghai Jihua Air Conditioning Engineering Contractual Responsibility Company has assumed contractual responsibility for transformation of a 2,500 square meter plant building that was turned over for use after only 4 months.

They have developed from coordination of key special scientific research topics to the integration of scientific research concerning multiple specializations and multiple disciplines and interdepartmental and interregional integration of specialized production.

They have developed from national coordination of research and development to international research and development.

They have developed from single item technical transfers to joint integrated administration.

The integration is providing advantages, speed and results, and it has been effective in promoting the development of economic construction. After the Guangzhou City Pharmaceutical Industry Research Institute linked up with the Guangzhou City No 4 Pharmaceutical Plant to form an association, research achievements in the institute were converted quickly into new products in the plant. The plant moved from losses to yearly profits in excess of 2 million yuan and there have been major improvements in the scientific research conditions and living conditions within the research institute. The Jialing Brand Motorcycle Association headed by Sichuan's Jialing Machinery Plant has made new investments of about 7 million yuan over the past 4 years to form a production capacity of annual output of 300,000 units and final assembly of 500,000 units a year. It has become the largest motorcycle plant in China in output, and it saved two-thirds of the investments needed for building a new enterprise of identical size.

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SSTC ON COOPERATION BETWEEN INSTITUTES, ENTERPRISES

Beijing GUANGMING RIBAO in Chinese 17 Dec 85 p 1

[Article: "Higher Education and Scientific Research Units Should Integrate With Large- and Medium-sized Enterprises--Guo Shuyan [6753 2885 6056], Deputy Director of the State Science Commission Talks With GUANGMING RIBAO Reporters--Forms Must Conform to Content, Be Concerned With Practical Results, Advocate Diversification and Do Not Act Indiscriminately"]

[Text] Guo Shuyan, deputy director of the State Science Commission, told reporters from the GUANGMING RIBAO that development of various forms of integration of scientific research and production should be accompanied by a concern for the integration of scientific research units and institutions of higher education with large- and medium-sized enterprises. There can be varied forms of integration. In conjunction with the short-term need for conscientious service to production, research units also should have specific technical reserves.

Guo Shuyan pointed out that most of the organizations that integrate scientific research with production in recent years involve links among scientific research and educational units with medium- and small-scale enterprises and township and town enterprises. They have played an obvious role in invigorating the local economy. This point must be acknowledged fully and should continue to develop in the future. At the same time, attention must be given to integration with large- and medium-sized enterprises. China's large- and medium-sized enterprises are the lifeblood of our national economy. Improvements in their ability to absorb and develop technology is linked with development of the national economy and improvement of technical levels. Some institutions of higher education and large and medium-sized enterprises in China should establish more linkages with them in various forms. Although it is true that key large and medium-sized enterprises depend on the motive force and vitality of technical progress to no lesser of a degree than medium and small-scale enterprises and township and town enterprises, further intensification of reforms in economic systems and increased vitality within the enterprises will make them increasingly dependent on technical progress. Scientific research and educational units in China should take note of this point.

While discussing the forms of integration between scientific research and production, Guo Shuyan also said that the forms of integration should conform to contents, be concerned with practical results, advocate diversification and avoid indiscriminate action. The actual forms adopted should be based on reality and conform to local conditions.

Guo Shuyan fully affirmed the role of scientific research and design units and institutions of higher education in the development of integration of scientific research and production. He also emphasized that at the same time that these units support their short-term need to serve production, they must also have a certain amount of technical reserves and continue to develop reserves so that integrated scientific research and production organizations can have even stronger vitality.

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NATIONAL DEVELOPMENTS

EFFECTIVE WAY TO PROMOTE TECHNOLOGICAL ADVANCEMENT

Beijing BEIJING KEJIBAO in Chinese 20 Dec 85 p 1

[Article by Jin Zhude [6855 2612 1795]: "The Civilianization of Military Technology Promotes Technological Advancement"]

[Text] After 3 decades of development, China's national defense, scientific and technological work has established a fairly solid, comprehensive and technically advanced foundation. We now have a large quantity of technology and advanced equipment and a scientific and technical contingent comprising highly qualified people. We have obtained a substantial number of technical achievements in the research and production of both conventional and nuclear weapons, some of them innovations in the nation and some reaching or approaching advanced international standard.

In line with the principle of military-civilian integration, the national defense scientific and technical industry in recent years has been actively transferring military industrial technology to the civilian sector even as it tries to fulfill our research and production tasks pertaining to weapons and armaments and continues to develop the production of civilian commodities. This transfer has powerfully boosted progress in civilian industrial, technological and economic development and provided obvious economic results. For instance, the Ministry of Aeronautics applied and popularized the satellite temperature control technology in such industries as textiles and metallurgy with excellent economic results in fuel conservatation, etc. They made the nation's largest heat pipe and exchanger for Anshan Iron and Stell Works, which not only shortens steel-smelting time and improves the productivity of a steel-smelting furnace, but also saves 700,000 yuan each year in fuel costs, equivalent to 3 times the unit price of hot pipe heat exchanger. In yet another example, the Ministry of Aeronautics used its technological superiority to help Tianjin integrate its output transformer production line with the result that the line's technological functional index reached advanced international standard. It also programmed microcomputers to control key equipment, increasing annual profits of each production shift by 1.2 million yuan. Nuclear technology has also been extensively applied in many areas including radiation processing, irradiation breeding, food preservation, sterilization and disinfection, medical diagnosis, tracer probing, analysis and surveying. Through the transfer of technological achievements to civilian sector, joint military-civilian research, the establishment of joint ventures with civilian

units, contracting, miscellaneous forms of economic and technical cooperation and the offering of extensive consulting services, the various national defense scientific, technical and industrial units are now transferring to the different sectors of the national economy technical wealth accumulated over many years.

Looking at events in recent years, the transfer of military technology to civilian use essentially takes the following forms: (1) the transfer of technical achievements (software); (2) the simultaneous transfer of technical software and hardware. This includes the transfer of technology along with the product as well as the application of military industrial technology to various areas of national economic construction through all manner of joint operation and contracting; and (3) military industrial personnel provide society with various kinds of technical services. Experience proves that the transfer of military industrial technology is an effective approach to promoting technical progress, integrating science and technology with production and raising the standard of social productive forces. As transfer became widespread, it has stimulated the rise and prosperity of the technical market and ushered the national defense scientific and technical industry into a new stage during which it contributes to the national economic development at various levels, in various forms and through various channels, even as it fulfills its tasks in weapons and equipment research and production.

Despite the initial achievements of the national defense scientific and technical industry in recent years in transferring military industrial technology to civilian use, the military industrial technology still has great potential and can play an even more important role in economic construction. To exploit to the full the technological superiority of military industry, the departments and localities concerned as well as military industrial enterprises, institutions and other units should take this vital force into consideration when they draw up development strategies at any level. We should further study and grasp the characteristics and laws of technology transfer and, on the basis of that knowledge, formulate and perfect a system for the transfer of military technology to civilian use together with relevant laws and regulations, and gradually solve such problems as funds and material channels so that the civilianization of military industrial technology can proceed more successfully and with better results.

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NATIONAL DEVELOPMENTS

NATIONAL DEFENSE SCIENCE, TECHNOLOGY DEVELOPMENT STRATEGY

Beijing BEIJING KEJIBAO in Chinese 20 Dec 85 p 1

[Article by Xi Qixin [1153 0796 2450]: "Conference on National Defense Science and Technology Development Strategy Held in Beijing"]

[Text] After 7 days of in-depth consideration and deliberations, the national defense science and technology development strategy conference closed in Beijing a few days ago. Research on national defense science and technology development strategy is an important component of building up a modern military with Chinese characteristics. Without such research, national defense science and technology research and weapons research will become haphazard and not be able to meet the needs of our military in future anti-aggression wars. The recent conference which examined the short-, medium- and long-range goals of China's arms development in a broad context, taking into account the country's conditions, was of profound significance for the development of our military. Leading comrades on the Central Military Commission urged comrades on the national defense scientific, technological and industrial front to carry on and strengthen our glorious, decades-old tradition of overcoming adversity, of diligence, struggle, self-reliance, unity, cooperation, courage, creativity and remaining undaunted in the face of difficulties.

The national defense science and technology development strategy conference was organized by the National Defense Science, Technology and Industry Commission and attended by over 200 experts and scientific and technical personnel from the headquarters of the General Staff, various arms of the services, relevant government ministries and departments and relevant units of the Chinese Academy of Sciences. This was the first time China organized such a large-scale conference to explore the national defense science and technology development strategy in a comprehensive and coherent way. Ma Hong [7456 3163], chairman of the Economic and Technological Research Center, the State Council; Ding Henggao [0002 5899 7559], chairman of the National Defense Science, Technology and Industry Commission; Zhu Guangya [2612 0342 0068], and Qian Xuesen [6929 1331 2773], chairman and vice chairman respectively of the Science and Technology Committee of the National Defense Science, Technology and Industry Commission, and other experts all presented papers at the conference dealing with various specialized topics. The conference has enhanced our understanding of the importance of national defense science and

technology development strategy research and our sense of urgency about stepping up such research. The conference also achieved a certain measure of agreement about the guiding ideology, procedures, contents, organization and methods of strategic research. Conference delegates believe that the meeting marks a new beginning in China's national defense science and technology development strategic work and will have a positive and far-reaching impact on defense modernization and national economic construction.

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NATIONAL DEVELOPMENTS

STATUS REPORT ON PATENT L[illegible]

Hong Kong JINGJI DAOBAO [ECONOMIC REPORTER] in Chinese 1 Jan 86 p 70

[Article by Wang Xidong [3769 2569 2639]: "Patent Law in Action"]

[Text] From 1 April 1985 when the "Patent Law of the People's Republic of China" came into effect on 9 September the same year, the State Patent Bureau received 9,867 patent applications, of which 6,080 applied for invention patents, 3,364 for utility and novelty patents and 423 for industrial design patents. Chinese enterprises, institutions and individuals were responsible for 6,632 applications while 3,235 were filed by foreigners.

On 10 September 1985, the State Patent Bureau held a press conference in Beijing at which Director Huang Kunyi [7806 0981 4135] announced the first batch of patent applications, including 46 applications in the invention category, 65 in the utility and novelty category and 39 in the industrial design category. Among them were 26 foreign applications and 43 individual applications.

At the same time, the State Patent Bureau has published a booklet on this batch of patent applications, another on the examination and approval procedures and a third on the application for a utility and novelty patent. They were made available for nationwide public distribution together with the announcement.

It is about these developments that the reporter interviewed Director Huang Kunyi. He said, "With the announcement of the first batch of patent applications, the implementation of the Patent Law has taken a big step forward. It shows that patent work is developing surely and steadily in China and that we have begun our own patent literature and are building up a comprehensive technical file on our own inventions and innovations, which should play an important role in the dissemination of information on inventions and the popularization of new technology."

Director Huang Kunyi said, "From now on, China's patent literature will be a new addition to the 30 million pieces of patent documents in the world collection today. We may say this is of historical significance."

He said, "New China's first Patent Law was promulgated and went into effect on 1 April this year. Earlier, on 14 September 1984, the Eighth Session of

the Sixth National People's Congress standing committee decided that China should join the 'Paris Convention on the Protection of Industrial Property' in order to cooperate with the world to promote such protection. After the Patent Law took effect, many enterprises and individual overseas indicated their desire to take out a Chinese patent and considered the promulgation of the law a landmark in the history of industrial property protection in the world. Over the past few months, the Patent Bureau received over 3,000 overseas applications, evidence enough of the high level of interest abroad in the establishment and implementation of China's patent system."

He pointed out, "Judging from the number of announced patent applications, the percentage of foreign applications remains quite small, about 1.7 percent of all announced patent applications. On the other hand, about 33 percent of all applications received by the Patent Bureau comprise foreign applications. Why?"

Director Huang Kunyi provided an explanation. He said, "As we all know, the Patent Law involves foreign relations as well as being a piece of domestic legislation. It was promulgated to develop China's economic and technical exchange and cooperation with the world as well as to protect domestic invention and innovation. The publication of the first batch of patent applications was based on three considerations: (1) patent applications made a request in their applications for substantive examination and early announcement; (2) the application papers were well prepared, which facilitates processing; and (3) the applications were submitted relatively early, the bulk of them on 1 April."

China and the rest of the world follow different timetables when it comes to announcing patent applications. Elsewhere, applicants usually request a time lag of 18 months before their applications are made public. This is another reason why the percentage of announced foreign applications is so small.

Director Huang Kunyi said, "China encourages foreigners to take out a patent in China. Our regulations provide that a foreign applicant who first applied for a patent abroad after 1 October 1984 may request priority in accordance with the law when he applies for a patent in China. The signs are that the percentage of foreign applicants will increase gradually."

Director Huang Kunyi said, "The Bureau's examination department has begun to classify patent applications and is carrying out the first round of preliminary examination. Some of the invention patent applications have entered the stage of substantive review. Relevant departments in the bureau are working intensively right now."

The State Patent Bureau currently employs over 200 substantive examiners in for substantive examinations departments each looking after different technical fields. All examiners hold scientific or engineering qualifications from institutions of higher education and most have considerable practical experience and are familiar with the techniques of their own specialties.

They have also been trained in the Patent Law and the practice of patent examination. In addition, the State Patent Bureau has specifically set up a classified file for inspection.

Director Huang Kunyi said, "In most cases examiners and applicants exchange opinions in the course of examination and many applicants amend their applications in accordance with the law."

About the publication of patent applications before the bureau approves them, he said, "We announce them to give people an opportunity to object to a particular application. This is also an important way of ensuring the quality of our examination and approval process."

He said, "Often the manufacturing method of identical or similar products is being researched, produced or applied in more than one unit, so the objecting process is essential to both research and production units. Say someone wants to take out a patent on a product or process which has already been published in journals, or been manufactured successfully by another unit and applied or popularized in actual production. In this case, the objecting process must be made full use of to prevent the person from obtaining the patent he seeks. Otherwise a patent dispute may possibly arise."

Director Huang Kunyi said, "Of course, the Patent Law provides that after a patent is granted, any person who knows of any reason why the patent should have been denied may ask the Patent Review Committee to declare the patent null and void. Still, 'prevention is much better than cure.'"

Director Huang Kunyi continued, "The Patent Law provides for a 3-month objecting period, beginning with the day when the application is announced. Only if no objection is raised during this period or if the objection is found to have no merit will the bureau proceed with the decision to award the patent and present the applicant with a patent certificate. The matter will be recorded and announced. Only at this point is the application considered to have been approved and only then does the patent formally take effect. But the Patent Law and its detailed regulations give temporary protection to a patent application after it has been published or announced, that is, after the substance of the invention or innovation becomes public knowledge. No individual or unit is allowed to use the invention at will. To use it, he must pay a use fee of an appropriate amount and obtain it through technology-transfer procedures."

Director Huang Kunyi said, "Under the Patent Law, a patent application is entitled to provisional protection only after the bureau has announced or published it. To help foreign readers keep track of China's patent information, therefore, China's patent bulletin and booklet will be distributed to various nations through exchange. Also, in the interest of easy reference, the Patent Bureau will publish a digest in English of patent applications in China in order to promote the interflow of patent information. At present

the Patent Bureau has established patent literature exchange relations with 14 nations and 2 international organizations." Director Huang Kunyi said that colleagues and patent experts overseas are welcome to raise objections to patent applications we have announced.

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NATIONAL DEVELOPMENTS

ANHUI GOVERNOR ON SCIENCE, TECHNOLOGY WORK

OW140419 Hefei ANHUI RIBAO in Chinese 2 Feb 86 p 1

[Excerpts of Governor Wang Yuzhao's speech at a meeting of the Anhui Provincial Scientific and Technological Association to greet veteran experts]

[Excerpts] Esteemed veteran experts and esteemed friends and comrades of scientific and technological circles:

With the advent of the first spring of our great motherland's Seventh 5-Year Plan, the provincial Scientific and Technological Association is holding this ceremonious meeting to greet the 80 veteran experts who have worked for 50 years in the field of science and technology. This is a happy event not only for the scientific and technological circles but also for the people at large in our province. On behalf of the Anhui Provincial CPC Committee and the provincial people's government, I respectfully extend warm congratulations and pay high respects to these veteran experts! I also wish to avail myself of this opportunity to extend sincere regards to all comrades working in the field of science and technology in the province.

Currently, we have entered a new period, a period for implementing the Seventh 5-Year Plan. To continuously advance on the basis of the excellent situation in our province, to further develop our urban and rural economies, and to turn our province's great blueprint for the Seventh 5-Year Plan period into splendid reality, the people across the province should work hard in unity under the party leadership and should continue to thoroughly implement the policy of reforming, opening, and invigorating. But in particular, we must speed up our technological advance, expedite the training of competent personnel, and increase the use of science and technology in supporting various tasks. This is an unshakable responsibility and an arduous but glorious task on the shoulders of comrades working on the science and technology front. In view of this, I wish to make the following earnest requests on behalf of the provincial CPC committee and the provincial people's government to all comrades present at this meeting and to the broad masses of science and technology workers in the whole province:

1. Persist in carrying out reforms and make continued efforts to thoroughly implement the decision of the CPC Central Committee on reform of the science and technology management system and the regulations promulgated by the provincial CPC committee and the provincial government relative to this reform.

It is imperative that we adhere firmly to the correct orientation in carrying out the reform in the field of science and technology. The objective of this reform is to fully arouse the initiative of the broad masses of science and technology workers so that their great "Potential" can be tapped through the implementation of correct policies. Success or failure of the reform in the field of science and technology depends on whether the initiative of science and technology workers has been stirred up, whether their work has produced greater results, and whether more new competent workers have been trained.

2. Mobilize to give more science and technology support in rural work. This is the key to further development of the rural economy. The No 1 Document (1986) of the party Central Committee stresses: The guidelines that "science and technology must serve the rural economy while the development of the rural economy must rely on science and technology" should be regarded as an important principle and given prominence. We hope that our comrades of science and technology circles will take account of our province's actual conditions, earnestly study and understand this principle, and enthusiastically provide rural areas with science and technology. They should educate peasants in science and technology. They should use science and technology to support village and town enterprises and provide complete technical service to peasants so as to help them solve the problem of poverty and become better off.

3. Go all out in the work of applied technological research and popularize the application of such research results, orient the work toward enterprises, open science and technology markets, and help enterprises promote technological transformation and advance. The enterprises now have a very urgent need for technological transformation and advance and are showing greater and greater capabilities to transform and develop themselves. In such circumstances, there is much for the broad masses of science and technology workers to do. They should orient their work toward the enterprises, enthusiastically provide the enterprises with good service, and work in concert with the enterprises' technical personnel to make due contributions to improving product quality; reducing consumption; assimilating, digesting, and improving foreign technology; accelerating the improvement of products; formulating development plans for the enterprises and even for the whole industry; improving operations and management; and raising overall economic results.

4. Earnestly train competent personnel and bring up a strong contingent of scientists and technicians. This is a glorious task that history has given to the scientific and technological circles as well as to education workers. We now have a relatively big contingent of scientists and technicians, but the numbers of scientists and technicians are still insufficient and their quality is not high enough. Because of this, they are far from adequate in meeting the needs of the four modernizations. In addition, the composition of our contingent of scientists and technicians is not entirely reasonable. As far as scientists and technicians are concerned, they have not only the task of scaling the heights of science but also the task of training new competent personnel and the task of making further studies to catch up with the development of advanced technology in the world.

5. Make more contributions to the work of building highly developed socialist spiritual and material civilizations. Scientists as well as the broad masses of workers in the science and technology field should, through their industrious work, promote not only material civilization but spiritual civilization as well.

6. It is hoped that the leadership at all levels will be concerned about the thinking, work, and livelihood of veteran experts as well as science and technology workers and support their work. It is necessary to make it a general practice in the whole society to respect knowledge and to honor competent people. Opinions and suggestions of science and technical workers should receive earnest attention, and their role should be brought into play in formulating macro policy decisions. In addition, it is necessary to know them well, make good use of their ability, and respect their pioneering spirit. Cases of attacking and persecuting science and technology personnel should be investigated and dealt with promptly. All these are aimed at further implementing the policy concerning intellectuals and bringing into full play the socialist enthusiasm of science and technology workers.

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NATIONAL DEVELOPMENTS

SHIFT IN NATION'S NUCLEAR INDUSTRY STRATEGY OUTLINED

Beijing LIAOWANG [OUTLOOK] OVERSEAS EDITION in Chinese 3 Feb 86 pp 3-4

[Article by Gu Mainan [7357 6701 0589] and Gu Wenfu [7357 2429 4395]]

[Text] Spring arrived early at Zhongnanhai this year. Although it is still in the middle of winter, willow trees along the shore are beginning to sprout, symbolizing that spring was around the corner.

In the afternoon of 21 January, ten scientists and engineers from the Ministry of Nuclear Industry joined by Minister Jiang Xinxiong and Deputy Minister Chen Zhaobo enthusiastically walked into the Huairen Hall of Zhongnanhai. Included in this group are the silver-haired nuclear-chemical engineer Jiang Shengjie, the nuclear physicist Wang Ganchang, senior engineers and scientists Liu Xingzhong, Min Yaozhong, Huang Qitao, Yu Min, Lian Peisheng, Qian Gaoyun, Lu Dexian, and Sun Zuxun. The ages of these gentlemen range from 78 to nearly 80. During the past three decades, they have struggled along with other colleagues from snowy highlands to the Gobi Desert, and have made outstanding contributions to the development of China's nuclear industry and strategic nuclear weapons, as well as to the peaceful use of nuclear energy. Now, the initial phase of nuclear development is behind us, and China is entering the period of the Seventh Five-Year Plan. The 300,000 workers of the nuclear industry are ready to write the next chapter in the history of nuclear development--a chapter on the peaceful use of nuclear energy.

The peaceful use of nuclear energy covers many different areas; an important question is to decide where to concentrate our national resources. When Party leaders and government officials announced that they wanted to meet directly with the scientists, the scientists were overjoyed and immediately went to work to prepare for suggestions which they brought with them to Zhongnanhai.

No sooner had the scientists taken their seats in the Huairen Hall, government leaders Hu Yaobang, Fang Yi, Li Peng, Yang Shangkun and Hao Jianxiu walked in. Minister Jiang Xinxiong introduced each one of the experts to the leaders, and after an initial round of socializing, they all gathered for a group picture. Hu Yaobang and Yang Shangkun walked over to Jiang Shengjie and Wang Ganchang and said: "Elderly comrades, please take the front seats!"

The meeting began in a lively and harmonious atmosphere. Hu Yaobang said: "Comrades in the nuclear industry, you have made valuable contributions for the Party, for the country, and for the people. Thanks to your dedicated efforts, we have successfully developed our own nuclear weapons, strengthened our defense posture, established a comprehensive nuclear industrial system, and built a top-notch team for the nuclear industry. The Party Central Committee, the State Council, the military services and the Chinese people will never forget the historical contributions you have made for us!"

In these few short statements, the General Secretary summarized several decades of hard work, dedicated pursuit, struggle, hardship, and joy of these experts and other personnel of the nuclear industry. Officials and scientists of the Ministry of Nuclear Industry were deeply moved by his remarks.

"The comrades indeed made a tremendous contribution." Interrupted Hao Jianxiu, smiling, "In 1964, as I was passing through Italy on my way home from Albania, I was unable to get an airline ticket. Just at that time, the news covering China's explosion of its first atomic bomb reached the airport, and knowing that I was from China, the airline personnel immediately sold me a ticket!"

Then Hu Yaobang continued his speech by saying that it was his hope that comrades in the nuclear industry would now diversify to support the development of consumer industries and to make new contributions for the cause of socialist economic development.

"Of course, in the past, you were in an ivory tower; everyone supported you and paved the way for you. Now, we hope you will take a few steps and come down from the ivory tower!" Hu said, with a smile. Everybody responded with laughter.

Prior to this meeting, Vice Premier Li Peng had toured several nuclear facilities including the Qinshan nuclear power plant which is currently under construction. He pointed out at the meeting that China's basic policy of nuclear development is to redirect its main resources to the development and utlization of nuclear energy while still maintaining the current level of military and industrial production. The first priority for the Ministry of Nuclear Industry should be to develop nuclear power; of course, they should also get involved in other consumer industries. The initial phase of developing China's nuclear power plants has been very difficult, but at least we have taken the first step. To develop nuclear power, we should consider self-reliance our primary goal, but we certainly will also take advantage of the advanced technologies from other countries.

He told the audience: "The Secretariat of the Central Committee and the State Council have made a preliminary decision to delegate the entire responsibility of research, development, and construction of nuclear power plants to the Ministry of Nuclear Industry. Therefore, comrades at the Ministry of Nuclear Industry will have greater freedom to apply their skills and talents. In making his remarks, Li cast a hopeful glance at the nuclear experts.

Hu Yaobang also agreed with Li's announcement about delegating more authority to the Ministry of Nuclear Industry. He hoped that various units of the Ministry would take the initiative to establish close contacts with local industries, other industrial and mining organizations, and small businesses in towns and villages, and send technical personnel to support these local activities. He also pointed out that in the area of peaceful use of nuclear energy, we can consider developing cooperative relations with other countries.

Next, Fang Yi took the floor and said: "It is also very important to maintain a strong research team in the nuclear industry by constantly recruiting new members. In addition to research in the peaceful use of nuclear energy, I am also hopeful that new contributions will be made in the areas of nuclear chemical engineering, isotope research, and laser research. In short, comrades of the Ministry of Nuclear Industry will have unlimited opportunities and a very bright future!"

Some experts at the meeting also expressed their opinions. They were particularly pleased to hear that the Ministry of Nuclear Industry will be given full authority to develop nuclear power. They pointed out that today, there are 26 countries capable of building their own nuclear power plants. In some developed countries, 50 percent of the energy supply comes from nuclear power. In building 10 nuclear reactors, we have accumulated considerable experience and established a comprehensive nuclear industrial system; we have also trained a highly qualified team of experts. With the full support and cooperation from other industries and organizations, we are confident that this important mission given to use by the Party and the State can be accomplished. Some experts pointed out that this assignment is what the 300,000 members of the nuclear industry have been hoping for. By the end of this century, total industrial and agricultural output will quadruple, hence the demand for electric power will also increase. If we rely totally on thermal electric power, the cost of transporting several million tons of coal from North to South will be unacceptably high, not to mention the adverse effect of environmental pollution. In order to solve China's energy problem in the 21st century, it is essential to follow the path of developing nuclear power; if we do not start now, it will be too late. Therefore, we believe that this decision by the Central Government is timely and correct. Some scientists observed that during the 50's and 60' when conditions were extremely difficult, we successfully built nuclear reactors in the Gobi Desert by relying on our own talents and resources; today's conditions are much better than those of that period. Furthermore, with today's open-door policy, we can supplement our own resources with advanced technologies from abroad; hence we have full confidence in successfully completing our mission.

The meeting concluded after more than 2 hours. The scientists left Zhongnanhai full of confidence and hope. After the meeting, they immediately conveyed the message to every worker in the nuclear industry. A major issue that had become a popular topic of discussion was how to adapt one's job to this shift in strategy. In this regard, Minister Jiang Xinxiong, Deputy Minister Chen Zhaobo, and scientists Jiang Shengjie, Wang Ganchang made some interesting remarks worth pondering. They said that the development of nuclear power plants, like the development of atomic bombs and hydrogen bombs, must depend on the cooperation of other ministries and departments. Relying on

the Ministry of Nuclear Industry alone is not sufficient. Although we have been given the primary responsibility, we must coordinate with other ministries and departments. In the development process, we must remember the valuable advice given by Premier Zhou Enlai: "Be serious in your work. Pay attention to details. Do not overlook any minor issues, no matter how small. That is the only way to ensure that nothing will go wrong." We can say that our mission is completed only after one, two, three reactors have been built and have been demonstrated to operate safely in a power network.

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CSO: 4008/43

NATIONAL DEVELOPMENTS

WEN WEI PO ON PRC'S ANTARCTIC RESEARCH

HK210559 Hong Kong WEN WEI PO in Chinese 17 Feb 86 p 2

["Newsletter from Antarctica" by correspondent Juan Chi-hung: "China's Scientific Research in Antarctica"]

[Text] In November last year, China sent another 39-man Antarctic observation team to conduct research at the Great Wall station on King George Island. Twenty-nine members of the team will spend summer there, while 10 others will stay through the winter and return to China early next year. What kind of scientific research are they doing exactly?

The land mass least known to mankind, Antarctica is also the only unpolluted continent, and a treasure house for scientific research. Geologists search for evidence in an attempt to prove whether the land was linked to the mainland or not million of years ago. A Beijing student who once settled down in the countryside in Xizang in 1966, Liu Xiaohan, is today a geologist with a doctorate degree from a French university. He believes that the South Shetland Islands (King George Island is part of this island group) were separated from the Antarctic mainland due to the sinking of land slates [ban kuai 2647 1040] some 2 million years ago, and that the South Shetland Islands are essentially an isolated island group similar to Japan and the Philippine archipelago. Data gathered by marine geologists indicates that the underwater gap between the South Shetland Islands and the Antarctic mainland measures 70 km, and the surface distance is 100 km.

Possible Oil Deposits

Liu Xiaohan carries a travelling bag and hammer and explores the area around the Great Wall station every day in search of evidence. He picks up rocks, notes down their exact location, marks the place, and brings the rocks back to the station for analysis. If it can be established that the South Shetland Islands are indeed an isolated island group, then more evidence should be available to further verify the proposition that Antarctica was linked to other great land masses further back in time. Liu has already found a tree fossil in King George Island which proves that the island used to belong to the Asian temperate zone. If it can be proved that this is an isolated island, then it is possible that oil deposits could be found on the sea bed, as has been the case with other isolated islands.

Giving Up Postgraduate School to Study Grey Dust

Jia Guoqiang, a young geophysist from Beijing University, gave up the chance to do postgraduate studies in the United States, and instead came to the Antarctic region to spend the winter here. His field of study is aerosols. In simple terms, aerosols are the suspended matter in the atmosphere, otherwise known as grey dust. Jia installed a tube-like sampling gadget with distilling papers placed at different levels in order to catch grey dust of various sizes. After gathering samples from different places and under different weather conditions, the samples will be brought back to China and put inside an accelerator, where they will be powdered and their components studied. This will be similar to grey dust which settled layer after layer on icebergs thousands of years ago, and should provide a valuable record of world climatic changes. Jia Guoqiang's study is significant in the study of world climatic history and weather forecasting.

This is an important item in the Antarctic research program. Air convection is not only an atmospheric problem. The United States uses airplanes to gather samples from all layers of the atmosphere in order to study the speed and direction of the spread of nuclear dust after nuclear bomb explosions. For its study of a nuclear winter, Australia burned an entire forest, then observed the weather changes under snow conditions. In Antarctica, there is no need to burn up forests in order to obtain freezing conditions.

Seismographs Were Also Installed

The United States and the Soviet Union have both installed seismic prospecting devices in Antarctica. The aim is to find out in which corners of the earth the other side has conducted nuclear tests. China also intends to set up a seismograph in the region. Aside from the above-mentioned purpose this will also be helpful in earthquake prediction.

Ordinary people only know how to appreciate the natural beauty of the Antarctic region, while scientists hope to learn about the varying weathering processes on the rocks of the mountains, to find out about the marine life beneath the calm waters and its distribution, hydrology, water temperatures, sea tides; and earth tides. All these fall into the sphere of study of oceanologists.

China's Antarctic scientific observation is just at the preliminary stage and a great deal of the work involves basic scientific research and collection of data. In fact, much of the work is repetition of work already completed by other countries. However, in the absence of a system for the exchange of scientific results, it is necessary for China to conduct this research. Moreover, this basic scientific research serves as a solid foundation for further research in the future.

/9604
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NATIONAL DEVELOPMENTS

NORTHEAST TECHNOLOGICAL DEVELOPMENT GROUP ESTABLISHED

SK180711 Shenyang Liaoning Provincial Service in Mandarin 2200 GMT 17 Feb 86

[Excerpt] The Northeast group for the application and development of new technology, an integrated economic and technological organization characterized by meeting the needs of opening to the outside, was formally established in Shenyang on the morning of 17 February. With the support of the three provincial governments in Northeast China, the group was jointly established by the Dalian Institute of Chemical Physics, the Changchun Institute of Optical and Precision Machinery, the Shenyang Institute of Automation, and the Shenyang Institute of Metal under the Academy of Sciences of China; the Ministry of Chemical Industry, the Shenyang Institute of Chemical Industry, Dalian Engineering College, Northeast Engineering College, Jilin University, Harbin Industrial University, the Shenyang Aircraft Industrial Company, the Shenyang (Lining) Machinery Company, and the Shenyang Company for the application and development of new technology on a mutually beneficial basis and in the light of the principle of voluntarily making concerted efforts for development.

/8309
CSO: 4008/2063

APPLIED SCIENCES

EMISSION MECHANISM OF OXIDE CATHODE

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol II No 2, Mar 83 pp 33-39

[Article by Zhang Enqiu [1728 1869 5876] of Institute of Electronics Chinese Academy of Sciences: "Electron Emission Mechanism of Oxide Cathode*"]

[Text] Abstract: The energy levels of single crystal BaO, SrO and CaO measured from thermal electrical conductivity, photoelectric conductivity, photoelectron emission and absorption spectra are so diverse that accurate energy band diagrams cannot be obtained. This suggests that the surface energy levels are more important than the bulk levels. The work function of single crystal BaO film on Ir(100) is single-valued. This is inconsistent with the wide distribution of total work function of carbonate measured by a low energy scanning electron probe, indicating that the semiconductor model cannot be used to accurately describe the oxide cathode. It was found that the coating was richer in oxygen than alkaline earth metal after 2000 hours by Auger electron spectroscopy. However, the capability to emit electrons was not affected. Thus, the oxygen vacancy donor concept is invalidated. The fact that excess barium are electron emission sources can be reconciled with decreasing alkaline earth metals during life by the dynamic surface emission center model. This model suggests that an aggregate of alkaline earth metal oxide molecules with excess absorbed barium atoms can effectively emit electrons. This concept can be used to interpret many phenomena observed on oxide cathodes using modern surface analysis techniques.

I. Introduction

Oxide cathodes are simple, efficient and widely used electron sources. However, there is still no satisfactory theory to describe their electron emission mechanism. In the semiconductor model introduced earlier[1,2], an oxide cathode is considered as a p-type semiconductor with excess barium as the donor. But, various theories derived from this model did not agree with phenomena observed experimentally. For example, the single crystal electrical conductivity, inhomogeneity of emission, instability at high current densities, and initial electron velocity distribution cannot be satisfactorily explained by the semiconductor model.

*Received in Jan 82, finalized in Mar 82.

We had analyzed a great deal of experimental data from China and abroad and proved that the semiconductor model does not agree with the essence of an oxide cathode[3]. Later, we introduced the dynamic surface emission center concept[4] in which an aggregate of atoms with excess absorbed barium is believed to be the electron source. In recent years, there has been some new data. Most of the work was done using advanced surface analyzers in ultra-high vacuum. These results further illucidated the essence of oxide cathodes. The purpose of this work is to re-examine our concept with the new data in order to investigate the characteristics of oxide cathodes.

II. Single Crystal Study

The basis of the semiconductor model is the single crystal. Then, a study of the single crystal could gain some profound understanding about oxide cathodes. In reality, however, single crystal measurement did not yield a clear concept. Instead, some serious discrepancies were found. Figure 1 shows the relation between electrical conductivity and temperature for single crystal BaO, SrO and CaO under different conditions.[5]

From the figure one can see that the zero scatter is considerably from either the numerical value of electrical conductivity or its slope (i.e. the internal work function in the semiconductor model). This is a surface state effect because the surface state is susceptible to the influence of the preparatory condition and the experimental environment. It is worthwhile to note that the electrical conductivity of the colored crystal (Curve 1) is higher than those of other transparent crystals. However, its internal work function is also higher (2.1 eV) than those of other crystals. It is also larger than the total work function of BaO (1.6 eV). The color in the center indicates the presence of trapped electrons in the oxygen vacancy, suggesting that the single crystal is in an excited state. A transparent single crystal then has no crystal defect, corresponding to a poisoned state. Experimental results showed that the internal work function of an excited single crystal is higher than that of a poisoned one. It is also larger than the total work function of BaO, which disagrees with practical oxide cathodes in use.

According to the semiconductor model, a cathode is activated by increasing the number of oxygen vacancy donors. The result is that the energy level of the donor will get closer to the conduction band to lower the internal work function. This also means that an increase in electrical conductivity should be related to a decrease in work function. However, Figure 1 shows that there is no specific correlation between the internal work function and electrical conductivity in a wide range of experiments involving different activation methods, annealing conditions and vacuum. This suggests that the activation concept in the semiconductor model cannot reflect the essence of oxide cathodes.

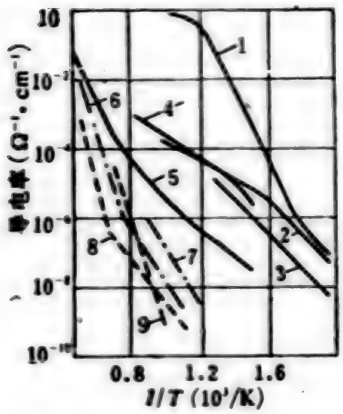

图 1 BaO、SrO、CaO 单晶导电率与温度倒数的关系

——BaO 1. 1473K钡蒸汽中染色的晶体；

2. 1000K真空中退色的透明晶体；

3. 真空中的透明晶体；

4. 甲烷中激活的晶体；

5. 不良真空下(10^{-2}Pa)的透明晶体。

—·—·SrO 6,7

-----CaO 8,9

Figure 1. Electrical Conductivity vs. Inverse Temperature for Single Crystal BaO, SrO and CaO

Key:

1. Dyed Crystal in 1437 K barium vapor
2. Transparent Crystal Discolored in 1000 K Vacuum
3. Transparent Crystal in Vacuum
4. Crystal Activated in Methane
5. Transparent Crystal in Poor Vacuum (10^{-2} Pa)

One can also see from Figure 1 that the electrical conductivities of SrO and CaO are far smaller than that of BaO. Their internal work functions (if they really exist) are larger than that of BaO, which indicates that the contribution of oxygen vacancy to electron emission in Sr and Ca is negligible. However, the electron emission of a composite crystal of mixed BaO, SrO and CaO is significantly higher than that of BaO. The total work function ϕ and temperature coefficients are as follows[6]:

$$\left.\begin{array}{rl} \text{BaO} & \phi=(1.6\pm0.08)+(5\pm1)\times10^{-4}T \\ \text{(BaSr)O} & \phi=(1.2\pm0.05)+(5\pm1)\times10^{-4}T \\ \text{(BaSrCa)O} & \phi=(1.1\pm0.05)+(5\pm1)\times10^{-4}T \end{array}\right\} \qquad (1)$$

where T is the absolute temperature. These experimental data were found to disagree with the derivation based on the semiconductor model. If we use the concept of the dynamic surface emission center, then the presence of Sr and Ca favors the formation of a low work function emission center which increases the energy levels to facilitate the transfer of surface electrons. It can absorb more excess barium atoms to prevent the evaporation of active materials[4]. These arguments are in agreement with the results obtained in practice.

In addition to thermoelectric conductivity discussed above, studies on pnoto-electric conductivity, absorption spectra and photoelectron energy spectra can be used to locate the energy level of the single crystal. Moreover, these results can be used for mutual verification. Nikonov attempted to obtain a clear energy level diagram by combining the data on BaO single crystal in these four areas. As he admitted that he was unable to plot an accurate energy band diagram from the available data. He believed that at least there are bulk energy levels at 1.2, 2.0 and 2.6 eV from the bottom of the conduction band to the donor as well as surface energy levels at 1.0, 1.4, 2.0 and 2.6 eV on the vacuum scale[5]. Although he did not get the anticipated result based on the semiconductor model, yet the data pointed out a problem. Even in a single crystal, the role of surface energy level is very important. It is even more so in a porous polycrystalline cathode.

It is clear that the semiconductor model for oxide cathodes cannot be verified by using single crystals. It is then not surprising that certain phenomena observed with polycrystalline cathodes could not be interpreted by this model. All objective facts forced us to focus our attention onto surface problem.

III. BaO Thin Film Deposited on Ir Substrate

Haas et al deposited a thin BaO film on Ir(100). It was used as a collector to observe the maximum and minimum current in the current-voltage curve with a single energy electron beam. The corresponding electron energies could be used to calculate the internal and external work functions. According to Bragg's reflection principle for a normal incident electron beam, the de Broglie wavelength of the electron, λ, in the conduction band of single crystal BaO should satisfy

$$n\lambda = 2d \qquad (2)$$

where d is the lattice constant and n is any integer. Let $\lambda = h/p$, h is Planck's constant, and P is the momentum of a conduction band electron, then the energy $\varepsilon = P^2/2m$ (m is the effective mass of the electron). After cancelling P and λ, we get

$$\varepsilon = \frac{h'^2}{2m}\left(\frac{\pi n}{d}\right)^2 \qquad n=1,\ 2,\ 3\cdots\cdots \qquad (3)$$

where $h' = h/2\pi$. When the electron energy in the conduction band satisfies Eq (3), electrons are reflected in the Bragg mode to form a standing wave, as shown in Figure 2. The collected current is the minimum. When n becomes (n-0.5), the electron wavelength is out of phase with the lattice constant and there is little reflection. The collected current is the maximum, i.e.

$$E\uparrow = \frac{h'^2}{2m}\left[\frac{\pi(n-0.5)}{d}\right]^2 + E_c \qquad n=1,\ 2,\ 3\cdots\cdots \qquad (4)$$

where E_t is the electronic energy corresponding to the maximum current. Because the Fermi level was used as the reference in the measurement, it is necessary to add E_c which is the energy from the bottom of the conduction band to the Fermi level. Haas et al believed that E_c is the internal work function and the external work function can be obtained by subtracting E_c from the total work function. Furthermore, they also measured changes of internal and external work functions under various conditions of thermal activation, electron bombardment and oxygenation poisoning[7,8].

Figure 2. Schematic Diagram of Standing Wave of Electrons in Conduction Band Lattice

Initially, this experiment seemed to support the semiconductor model for oxide cathodes. Haas et al had the same feeling. However, a detailed analysis showed that it could not be used as evidence to prove an oxide cathode is an n-type semiconductor because:

1. The key to the semiconductor model is in the donor. In this experiment, electrons are injected into BaO and they move in the conduction band. Those not reflected enter the iridium substrate to become the measured current. Therefore, the entire experiment did not involve any donor activity. Because donors are distributed all over the thin film, the standing wave shown in Figure 2 would be destroyed if donor electrons jumped to the conduction band or conduction electrons down to the donors. Then, Eq (2) could not be satisfied. This is in contradiction to the basic principle of the experiment. The work functions measured in that work were due to the surface states at the BaO-Ir and BaO-vacuum interfaces. The changes of E_c with activation or doping is probably due to adsorbed oxygen on iridium just as measured with an Auger spectrometer shown in reference [8]. This phenomenon can be explained by the concept that the work function can be lowered if an appropriate amount of oxygen is adsorbed on the metal surface, but too many adsorbed oxygen atoms will cause it to rise again.

2. The experiment was conducted at room temperature with an injection current less than 1μA, which is far different from the operating condition of an oxide cathode. Therefore, the results cannot illucidate the mechanism of an oxide cathode. The same group adopted an opposite approach to develop a practical cathode by covering an iridium film on BaO. In addition, the BaO was not monocrystalline. They discovered that active materials could diffuse along the iridium surface. When using an electron microscope, they were able to cleanly observe emission centers[9], suggesting that appropriate aggregates on the metal surface might also emit electrons. This coincides with the concept of dynamic surface emission sites.

3. In an article published later, Haas[10] had changed his opinions in references [7,8]. When they injected a $2\times10^{-3}A/cm^2$ electron beam onto a BaO single crystal film, the electrical conductivity was found to be greater than $4\times10^{-8}(\Omega\text{-cm})^{-1}$, which is two orders of magnitude higher than that of BaO single crystal at the same temperature, $10^{-10}(\Omega\text{-cm})^{-1}$. Hence, it could not be explained by the electrical conduction mechanism in a semiconductor. Consequently, they introduced the surface conduction concept. After measuring the temperature coefficient of the work function of single crystal and polycrystalline BaO, they found that their temperature coefficients are basically identical. The work function of polycrystalline BaO is lower. They were forced to believe that the variation of the work function with temperature is not due to Fermi energy changes in the bulk. Instead, it is affected by the surface state, i.e. the external work function. In addition, when they were determining the external work function of M_gO on single crystal Mo(100), concepts such as Fermi energy level, forbidden bandwidth and internal work function were not used. This shows that the team was in the process of exploring the truth and they did not believe that their viewpoints should remain unchanged.

IV. Research on Practical Oxide Cathodes

Haas et all studied ternary salt cathodes in detail and obtained a lot of useful data[12]. First they used a low energy scanning electron probe technique to measure the work function distribution of ternary salts at 915 K as shown in Figure 3. We can see that the difference between high and low work function is above 1 eV. This is difficult to interpret by the semiconductor model. Because each particle is in contact with others, electrons can move freely in the conduction band as long as they jump from the donors to the conduction band. Even though the donor concentration in the coating is not uniform, the electron concentration in the conduction band is still homogeneous because electrons can move easily. Therefore, the inhomogeneity of electron emission is primarily due to difference in the external work function. But, the numeric value of external work function is less than 1 eV according to the literature (measured based on the semiconductor model). Therefore, it cannot be responsible for such a large scatter. If the dynamic surface emission center concept is employed, barium may be adsorbed on BaO, SrO or CaO, and the relative amount and adsorption position are different. Hence, the ability of each atomic aggregate to emit and transfer electrons is different. Moreover, each emission center is essentially independent. A large work function distribution may result due to the difference in the structure and nature of the aggregate.

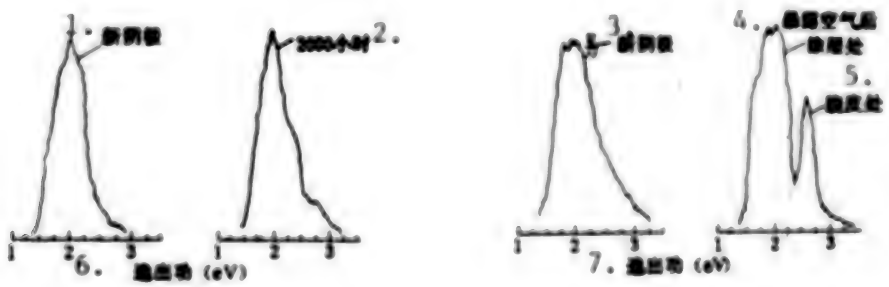

Figure 3. Distribution of Ternary Salt Work Function Measured with a Low Energy Scanning Electron Probe

[Key on following page]

Key:

1. New cathode
2. 2000 hours
3. Another new cathode
4. Coating after exposure to air
5. Peeled spot
6. Work function (eV)
7. Work function (eV)

In addition, there was one measured work function according to references [7,8]. This value is not the effective work function based on the measuring principle. If it indeed is the average, then there should not be a maximum and a minimum current. There are no extrema in polycrystalline metals. Therefore, the single crystal BaO on iridium system does not reflect the essence of a practical cathode. This point was discussed in the previous section from a different angle.

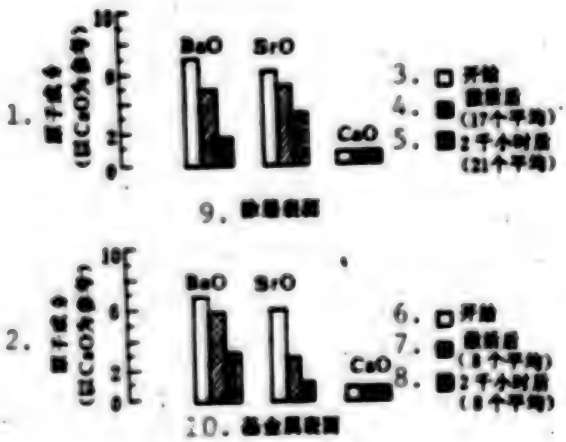

Figure 4. Variation of Alkaline Earth Metal Oxide at Coating Surface and Substrate Interface

Key:

1. Atomic Composition (relative to CaO)
2. Atomic Composition (relative to CaO)
3. Initial
4. Activated (average of 17)
5. After 2000 hours (average of 21)
6. Initial
7. Activated (average of 8)
8. After 2000 hours (average of 8)
9. Coating surface
10. Metal substrate surface

Because barium vaporizes easily relative to CaO, the composition of the ternary salt changes significantly in the life cycle. Figure 4 shows the changes in BaO and SrO relative to CaO. Active materials decreased at the surface as well as at the substrate interface. However, the emission characteristic of the cathode (i.e. the value of the effective work function ϕ) basically remains unchanged (see Table 1)[12]. Furthermore, the work function distribution does not vary by much after 2000 hours of life (see Table 3). According to the semiconductor model, the electron emission comes from donors in the bulk. However, the contribution from SrO and CaO was found to be far less than that of BaO in the single crystal study described above. Therefore, any change in the composition of the coating will result in a change in emissivity. After activation, the amount of BaO is decreased (see Figure 4), while the emissivity is increased. In the later stage in life, BaO is further decreased and there is little change in emission. These results cannot be explained by using the semiconductor model. If the dynamic surface emission center concept is employed, then thermal activation, which makes barium migration easier, will favor the formation of emission centers. In the life cycle, some centers are destroyed and other centers are created due to evaporization, poisoning and sputtering. These centers are localized and do not require a large amount of barium. Therefore, stable emission can be maintained even when the coating composition changes significantly.

Table 1. Variation of Composition, Preparation Technique and Work Function in a Life Cycle

	Cathode Preparation	Coating Properties				
		Alkaline Earth Metal Content (Atomic %)			O/O*	At 818K ϕ_e (eV)
		Ba	Sr	Ca		
New Cathode	1. 喷涂(6个平均)	44	49	7	0.97	1.84
	2. 印贴(5个平均)	44	48	8	0.99	1.84
	3. 印贴(2个平均)	41	49	10	1.08	1.88
	4. 印贴重激活(4个平均)	43	46	11	1.01	1.85
After 2000 hours	5. 印贴重激活(7个平均)	24	59	17	1.41	1.84
	6. 印贴重激活(19个平均)	29	58	18	1.43	1.84

Key:

1. Spray painted (average of 6)
2. Press-plasticized (average of 5)
3. Press-plasticized (average of 2)
4. Press-plasticized with reactivation (average of 4)
5. Press-plasticized with reactivation (average of 7)
6. Press-plasticized with reactivation (average of 19)

The variation of the oxygen content is another parameter which reflects the nature of the oxide cathode. In reference [12], the oxygen required to react with the alkaline earth metal was defined as 0*. The ratio of the actual measured oxygen content 0 to 0* is shown in Table 1. 0/0* is close to 1 regardless of the preparation technique, which is understandable. The 0/0* ratios at various parts of the cathode after 2000 hours are shown in Table 2. One can see that it is oxygen rich throughout the coating. But, the level of emission does not decrease. Therefore, the concept of oxygen vacancy donor in the bulk is not valid. Thus, the semiconductor model was invalidated. However, we cannot deny that excess barium has two high energy electrons which can emit to vacuum easily, all low work function, practical cathodes contain barium. This is a result of long term practice.[1,2]

Table 2. Ratio of Measured and Stoichiometric Oxygen Content at Different Parts of the Cathode (After 2000 Hours)

Position	Coating Surface	Sputtered 260Å	Peeled Coating (still with residue)	Base metallic substrate
0/0*	1.42	1.22	1.14	1.01

In reference [12], excess barium was defined by substracting the average amount of barium in the composition from the measured barium content. After 2000 hours of service, the distribution of elements in various parts of the cathode is shown in Figure 5. One can see that with the exception of the coating surface (1), which was used as the reference, other parts had excess barium. At the substrate surface and near the substrate, there were more excess barium (locations 4 and 5). Even at location 1, barium could still adsorb on SrO or CaO to form an emission center. Barium can migrate to a distant location, while Sr and Ca cannot. This suggests that the loss of barium might not be purely due to vaporization. There is also migration. This coincides with the activation concept in the dynamic surface emission center model. The activation of the cathode is not only happening in the initial high temperature treatment, it also occurs throughout the entire service life. Although the entire coating is oxygen rich, yet locally excess barium may still adsorb on the alkaline earth metal oxide aggregates. It is more probable to have such aggregates on the substrate surface. It is easier to get replenished after emitting electrons. Therefore, the metal surface bears more current. However, this does not mean that the coating is useless. It supplies excess barium and prevents gas poisoning and ion sputtering to protect the emission center.

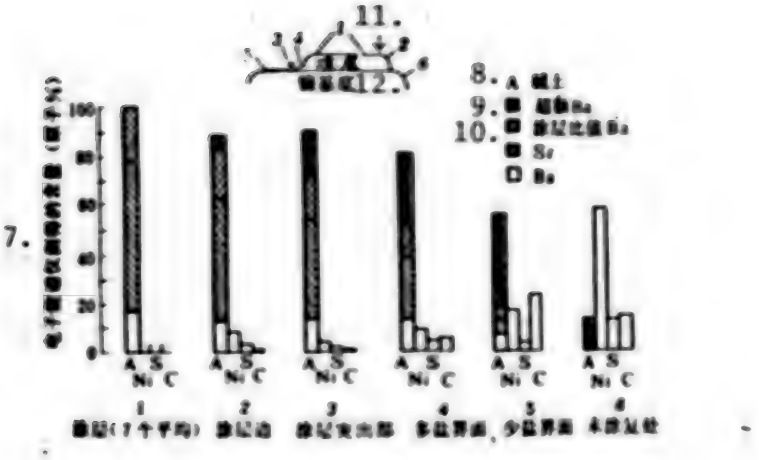

Figure 5. Contents of Various Elements in Different Parts of the Cathode After 2000 Hours

Key:

1. Coating (average of 7)
2. Coating edge
3. Protruding coating
4. High salt interface
5. Low salt interface
6. Uncoated area
7. Content measured by electron energy spectrometer (atomic %)
8. Alkaline earth
9. Excess Ba
10. Stoichiometric Ba content in the coating
11. Coating
12. Nickel substrate

V. Conclusions.

In summary, to demonstrate the accuracy of the semiconductor model, it is necessary to experimentally prove that (1) electrons indeed jump from donors in the bulk to the conduction band, (2) the electron concentration in the conduction band is sufficient to make the crystal electrically conductive, and (3) the emission current density is proportional to the square root of donor concentration. Unfortunately, such experiments did not materialize in several decades. In addition, many new phenomena unveiled by modern surface analysis techniques put this model in an even more difficult position. The dynamic surface emission center concept can better explain these new phenomena after summarizing the long term operating experience of hot cathodes. It seems to be a hopeful model.

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APPLIED SCIENCES

THEORY, CALCULATION OF LARGE SIGNAL CUT-OFF ZONE IBCFA

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol II, No 2, Mar 83 pp 45-51

[Article by Zhou Ping [0719 1627], Wu Boyu [0702 0130 3842], and Zhang Keqian [1728 0344 3383] of Department of Radio Electronics, Qinghua University: "Theory and Calculation of Large Signal Cut-off Injected Beam Cross Field Amplifiers (IBCFA)"]

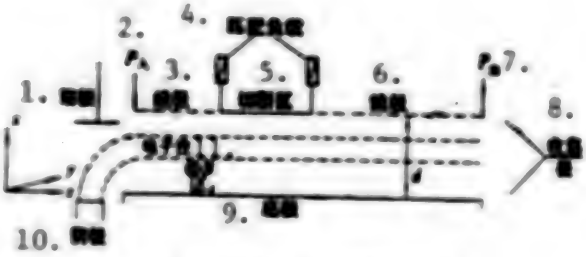
[Text] Abstract: In a high gain injected beam cross field amplifier, the presence of a cut-off zone in the slow wave system is unavoidable. In this work, a physical model describing the drift process of a density modulated electron beam through the cut-off and the re-excitation of the slow wave by the high frequency field after the cut-off was introduced. The mathematical derivation and theoretical formulas are presented and a FORTRAN program was compiled. The results show that its error relative to experimental values is 7-20 percent. The length and position of the cut-off and the effect of electron drift in the cut-off on the power output were revealed by a series of calculations. The technique and program used in this work can be applied in CAD of IBCFA.

I. Introduction

We are well aware that it is impossible to totally eliminate reflected waves in a microwave tube. In order to cut off the feedback circuit and to suppress resonance, a cut-off zone must be installed in a high gain IBCFA (see Figure 1, P_{in} and P_{out} are the power input and output, E_d and B are the dc electric field and the magnetic induction intensity and d is the distance between the two electrodes).

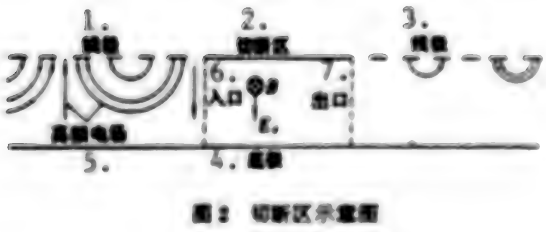
The complex physical process in the cut-off zone has not been comprehensively discussed in the literature to date. Zhang Keqian[6] presented the formula for small signal thin electron beam in the cut-off zone. In the area of large signals, some authors did not take the cut-off zone into consideration in their theoretical calculations for IBCFA. Other authors[1,2] only considered a zero length cut-off and did not include the Diocotron effect in the cut-off zone, which caused some error in the final result. Yu[3] published a theoretical calculation technique for large signals in the Model M device. However, the actual calculation is not yet reported. Shu Shiwei [5289 0013 3956] et al[4] compiled an IBCFA program based on Yu's theory. However, it also did not involve the cut-off zone problem.

In the computer aided design (CAD) of IBCFA, it is significant to quantitatively study the length and position of the cut-off zone and the effect of electron drift in the cut-off zone on the properties of the tube. In this work, a comprehensive physical model is introduced. The drift process and the buildup of the high frequency field at the outlet of the cut-off zone were considered. Furthermore, on the basis of Shu's work, we compiled a computer program (in FORTRAN) for IBCFA including the cut-off zone to conduct calculations. Yu's model and formulas were used in the interaction region and the details are not repeated here.



Key:
1. anode
2. P_{in}
3. line
4. matching load
5. cut-off zone
6. line
7. P_{out}
8. collector
9. base
10. cathode
11. injected electron

Figure 1. Schematic Diagram of the Structure of an IBCFA



Key:
1. line
2. cut-off zone
3. line
4. base
5. high frequency electric field
6. entrance
7. outlet

Figure 2. Schematic Diagram of the Cut-off Zone

A cut-off zone is equivalent to a drift zone without any high frequency field (see Figure 2). Therefore, the physical process in the cut-off zone can be simplified as the following physical model.

Let us assume that the high frequency cutoff in the cut-off zone is zero and there are only dc electric field, dc magnetic field and space charge field in the cut-off zone. A high frequency current is induced in the slow wave

structure after a density modulated electron beam drifting through the cut-off zone. It is excited by the high frequency field and continues to interact with the escaped electron beam to complete the energy exchange process. The amplitude and phase of the RF field are totally determined by the induced current on the slow wave line.

2. Electron Drift Process in the Cut-off Zone

Because the high frequency line is zero in the cut-off zone, only the space charge field and the dc electromagnetic field will affect the motion of electrons. All we have to do is to find the space charge field by letting the amplitude of the high frequency field in the cut-off zone equal to zero.

3. Calculation of Induction Current At the Cut-off Zone Outlet

The electron beam is density modulated in front of the cut-off zone. Therefore, it is distributed periodically. Let us assume that the period is λ_r and neglect minor variations between neighboring cycles, then the charge distribution can be decomposed into the sum of time harmonics as follows:

$$\rho(x',y',t)=\sum_{\gamma=0}^{\infty}[{}_c\rho_\gamma^{(K)}\cos(K\omega t-K\beta_\gamma y')-{}_s\rho_\gamma^{(K)}\sin(K\omega t-K\beta_\gamma y')] \qquad (1)$$

where P(x', y', t) is the charge density at x', y' at time t, ${}_cP_x^{(K)}$, and ${}_sP_x^{(K)}$ are the Fourier transform coefficients of the space charge on the x' plane at t=0:

$${}_c\rho_\gamma^{(K)}=\frac{2}{\lambda_r}\int_0^{\lambda_r}\rho(x',y',0)\cdot\cos K\beta_\gamma y'\,dy',\quad {}_s\rho_\gamma^{(K)}=\frac{2}{\lambda_r}\int_0^{\lambda_r}\rho(x',y',0)\sin K\beta_\gamma y'\,dy',\quad \beta_\gamma\,(=2\pi/\lambda_\gamma)$$

is the phase constant of the γth space harmonic, ω is the angular frequency of the high frequency signal, x' and y' represent the coordinate in a static coordinate system which is related to a moving coordinate x, y (at a speed of ω/β_γ) as follows:

$$x'=x,\qquad y'=y+\int_0^t\frac{\omega}{\beta_\gamma(t)}dt=y+l \qquad (2)$$

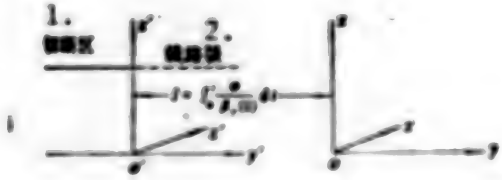
Let us assume that the origins of these two coordinates coincide at the exit of the cut-off zone at t=0 (see Figure 3).

According to the formula given by Rowe[2], if only the fundamental wave component of the charge distribution is considered, then the space charge $P^{(1)}$ is related to the induced charge $P_i^{(1)}$ according to the following:

$$\rho_i^{(1)}(y',t) = -\frac{1}{h}\int_0^d \rho^{(1)}(x')\rho^{(1)}(x',y',t)\,dx' \qquad (3)$$

$$\rho^{(1)}(x') = \mathrm{sh}\beta_1 x'/\mathrm{sh}\beta_1 d \qquad (4)$$

where h is the width of the electron beam in the z direction and the superscript "(1)" represents the fundamental wave component.



Key:
1. cut-off zone
2. line

Figure 3. Relation Between the Two Coordinates

In a Model M cross field device, the x component of the electron velocity, v_x, is much smaller than the y component V_y. In addition, V_y is very close to the cold synchronous speed $v_{eo}=E_d/B$. Therefore, the electron velocity can be approximately considered as v_{eo} when we determine the induced current at the exit of the cut-off zone. Thus, the alternating fundamental wave component of the space convection-current density is:

$$J^{(1)}(x',y',t) = \rho^{(1)}(x',y',t)\cdot v_{eo} \qquad (5)$$

The space charge moves in the y' direction at a speed of v_{eo}. The corresponding induced current should also flow at the same speed and the induced current alternating fundamental wave component is

$$I_i^{(1)}(y',t)=\rho_i^{(1)}(y,t)\cdot v_{e0}$$

$$=-kv_{e0}\int_0^d[\rho_e^{(1)}\cos(\omega t-\beta_y y')-\rho_o^{(1)}\sin(\omega t-\beta_y y')]\frac{\mathrm{sh}\beta_y x'}{\mathrm{sh}\beta_y d}dx'$$

$$=-\frac{v_{e0}k}{\mathrm{sh}\beta_y d}\rho_m\cos(\omega t-\beta_y y'+\varphi) \qquad (6)$$

where

$$\rho_m=\left\{\left[\int_0^d\rho_e^{(1)}(x')\mathrm{sh}\beta_y x'\,dx'\right]^2+\left[\int_0^d\rho_o^{(1)}(x')\mathrm{sh}\beta_y x'\,dx'\right]^2\right\}^{1/2} \qquad (7)$$

$$\varphi=\mathrm{arctg}\left[\int_0^d\rho_e^{(1)}(x')\mathrm{sh}\beta_y x'\,dx'\Big/\int_0^d\rho_o^{(1)}(x')\mathrm{sh}\beta_y x'\,dx'\right] \qquad (8)$$

In the moving coordinate system, the induced current $I_1^{(1)}$ becomes

$$I_i^{(1)}(y)=(-v_{e0}k/\mathrm{sh}\beta_y d)\rho_m\cos(\beta_y y-\varphi) \qquad (9)$$

In the coordinate moving at a speed of $\omega/\beta\gamma$, the high frequency field propagating on the slow wave line can be decomposed into the following space harmonic waves[3].

$$\left.\begin{aligned}E_e^{(1)}&=\sum_{n=-\infty}^{\infty}A_n\frac{\mathrm{ch}\beta_n x}{\mathrm{sh}\beta_n d}\sin\left[\int_0^t\omega\left(1-\frac{\beta_n}{\beta_y}\right)dt-\beta_n y\right]\\ E_o^{(1)}&=\sum_{n=-\infty}^{\infty}A_n\frac{\mathrm{sh}\beta_n x}{\mathrm{sh}\beta_n d}\cos\left[\int_0^t\omega\left(1-\frac{\beta_n}{\beta_y}\right)dt-\beta_n y\right]\end{aligned}\right\} \qquad (10)$$

We are concerned with the γth harmonic of the high frequency field which is capable of interfacing with the electron beam in synchronization. In the time harmonics of the induced current, only the fundamental component $I_1^{(1)}$ has the same frequency as the I harmonic, which is why it can be used in the excitation.

According to the equivalent circuit theory, when a high frequency current encounters a slow wave line with an impedance Z_γ, the mean power transmitted on an equivalent line is $P=\frac{1}{2}\left|I_\gamma^{(1)}\right|^2Z_\gamma$. Because $Z_\gamma=A_\gamma^2/2\beta_\gamma^2P$, the amplitude of the high frequency field excited by the induced current $I_1^{(1)}$ is $A_\gamma=|I_\gamma^{(1)}|\cdot Z_\gamma\beta_\gamma$.

At the exit of the cut-off zone, there is not enough time for the field to interact with the charges. The initial high frequency field is determined by the induced current. Therefore, the RF field should be in phase with the induced current, i.e. the field should have the same initial phase angle "$-\varphi$".

$$\left.\begin{aligned} E_x'^{(0)} &= -A_\gamma(\mathrm{ch}\beta_\gamma x/\mathrm{sh}\beta_\gamma d)\sin(\beta_\gamma y-\varphi) \\ E_y'^{(0)} &= -A_\gamma(\mathrm{sh}\beta_\gamma x/\mathrm{sh}\beta_\gamma d)\cos(\beta_\gamma y-\varphi) \end{aligned}\right\} \qquad (11)$$

From the above formulas we can see that the phase of the newly excited high frequency field in the moving coordinate is shifted by an angle φ relative to that in front of the cut-off zone.

III. Analysis and Discussion of Calculated Results

We compiled a FORTRAN computer program based on the above theory and conducted calculations for two tubes with actual parameters. In the calculation, the electron beam was injected parallel to the entrance of the interacting region. The electron injection is divided into three layers and each layer consists of 128 charge rods. There are a total of 384 charge rods.

1. Comparison of Calculated and Experimental Results.

We calculated two cut-off zone injected beam cross field tubes: (1) the "K-31" tube developed by Qinghua University with a 102 mm long first gain section, 63 mm long cut-off zone, and 194.5 mm long second gain section; and (2) the "L-3974" tube developed abroad[5] with a 114 mm long first gain section, a 12.7 mm cut-off zone, and a 165.1 mm long second gain section. The operating parameters and calculated results are shown in Tables 1 and 2. In these tables, the symbols represent that: f is the frequency, Z_r is the coupled impedance, V_L is the line voltage, V_s is the base voltage, α_1 and α_2 are the attenuation coefficients of the first and second gain circuit, B is the dc magnetic field, I is the injected electron current, P_{in} is the power input, P_{out} is the power output, G is the power gain, η is the efficiency, $P_{out-cal}$ and $P_{out-exp}$ are the calculated and experimental power output data, respectively.

Table 1. Operating Parameters

管 1. 型	f(Hz)	$Z_r(\Omega)$	V_L(V)	V_s(V)	$\alpha_1'\left(\frac{dB}{m}\right)$	$\alpha_2'\left(\frac{dB}{m}\right)$	B(Wb)	I(A)	P_{in}^2(W)
K-31(13°-1)	f_1^*	12.4	7500	-5800	12.4	16.7	0.1425	0.5	10
K-31(12°-1)	f_2^*	11.2	7500	-5000	12.4	16.7	0.1368	0.5	10
L-3974	14.0×10^9	0	10500	-4390	11.8	11.8	0.2773	0.255	2

3. * f_1、f_2均为C波段频率。

Key: 1. tube type; 2. P_{in}(W); 3. f_1 and f_2 are c-band frequencies

Table 2. Comparison of Calculated and Experimental Results

管 1. 型	2. 实验数据			计算 3. 结果			4. 功率相对误差 $\left(\frac{P_{出计}-P_{出实}}{P_{出实}}\right)$
	5. $P_{出}$(W)	G(dB)	η	6. $P_{出}$(W)	G(dB)	η	
K-31(13°-1)	830	19.2	22.1%	998	19.99	26.6%	20.2%
K-31(12°-1)	600	17.8	16%	642	18.1	17.1%	7%
L-3974	500	24	18.7%	598	24.6	22.3%	19.6%

Key:

1. tube type
2. experimental data
3. calculated results
4. relative power error $(P_{out\text{-}cal}-P_{out\text{-}actual}/P_{out\text{-}actual})$
5. P_{out}(W)
6. P_{out}(W)

From Table 2 we can see that the calculated results are slightly higher, which might be due to the determination of the attenuation coefficient α' of the circuit. Near the output end, electrons are captured by the line. In addition, the thermal consumption is also increased due to the high power frequency. These two factors cause the temperature on the line surface to rise, leading to higher resistance and increasing line attenuation coefficient α'. In our calculation, the value of α' used was measured at a colder temperature, and is smaller than the actual value. We conducted a series of comparison calculations for the L-3974 tube (the initial electron drift velocity is different from that listed in Table 2 for the L-3974 tube). When the cold measured value of α' is 11.8(dB/m), the power output is 320 W. If we assume that the average temperature on the line is 250°C, the calculated α' is 16.3 and the power output is 217 W. If the latter is correct, then the relative difference is 47%. Thus, the value of α' has a great impact on the power output.

In summary, the calculated values are close to the experimental ones. If the line attenuation coefficient α' is properly corrected, then the error will be even smaller. This indicates that the physical model is capable of describing major factors of the physical process in the sever. Our program is sufficiently accurate as an ancillary tool for the design of IBCFA devices to provide data to indicate the effect of various physical parameters.

2. Effect of Electron Drift on Power Output.

Curve 1 in Figure 4 represents a zero length of the cut-off zone, i.e. the high frequency field abruptly drops to 0 at 102 mm. A newly excited field due to induced current exists from that point onward. Curve 2 represents the situation in which the cut-off zone length is 63 mm. We can see that the

un-saturated power of Curve 1 is always higher than that of Curve 2. This is because the second gain slow wave line of Curve 1 is 63 mm longer than that of Curve 2. When the tube length is fixed, the longer the cut-off zone is, the shorter the second gain section becomes, which does not favor an increased power output.

In real tubes it is impossible to have zero length of the cut-off zone. Curve 1 was moved laterally by 63 mm to obtain Curve 3. It is equivalent to the newly excited high frequency field at the actual exit of the sever by taking the length of the sever into account, but excluding the effect of the drift process (which is the treatment of Hull and Howe). From Figure 4 we can see that the un-saturated power output of Curve 3 is always lower than that of Curve 2. The difference at the output is nearly 300 W. This comparison clearly demonstrated that electron drift in the sever has a great effect on the power output. Because electron clusters are improved by the "Diocotron" effect, the interaction between escaped electrons and the field is more complete and intense. Results of this calculation show that it may be feasible to assume a zero length cut-off zone and to neglect electron drift when the cut-off zone is short. However, the error introduced into the power output cannot be neglected when the cut-off zone is long.

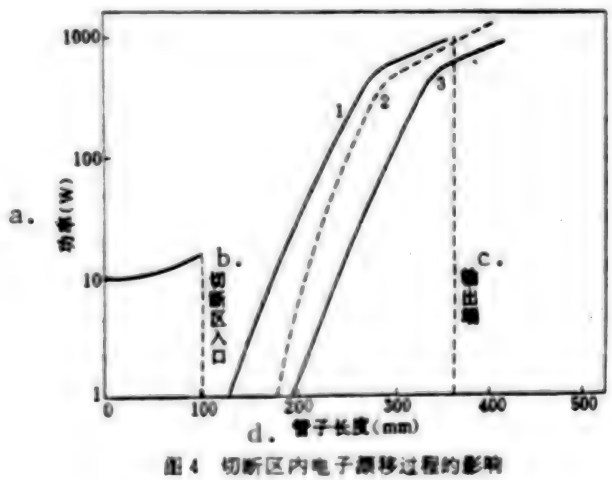


图4 切断区内电子漂移过程的影响

Figure 4. Effect of Electron Drift in the Cut-off Zone

Key:

a. power (W)
b. cut-off zone
c. output end
d. tube length (mm)

Figure 5 shows computer simulated electron cloud patterns of a K-31 (13#-1) tube, which illustrate the electron clusters in the tube and the field - charge interaction process. Each electron cloud pattern is an electron distribution of a monitored slow wavelength λ_r at a specific time. "T" represents the time

lapse after electrons are injected (in units of spin period T_C). The Arabic numbers shown in the interaction region represent the charge rod at that point (a total of 384 rods in the calculation).

Before entering the cut-off zone (T=12), the electron cluster is very weak. It is still possible to find traces of three parallel laminar, but non-uniform layers (to simplify the calculation, we assumed that electrons were injected in three uniform parallel laminar layers). This suggests that there is some kind of density modulation. After drifting into the cut-off zone, electron clusters begin to take shape at the exit of the cut-off zone (T=24). As electrons continue to interact with the field, the clustering of electrons and the high frequency field continue to intensify. Electrons are clustered together in the repulsive field (T=48), and its position is rising. The potential energy of the electrons is converted into RF energy (output end, T=54), until most of the electrons have struck the line and the RF power is reaching a saturation (T=60).

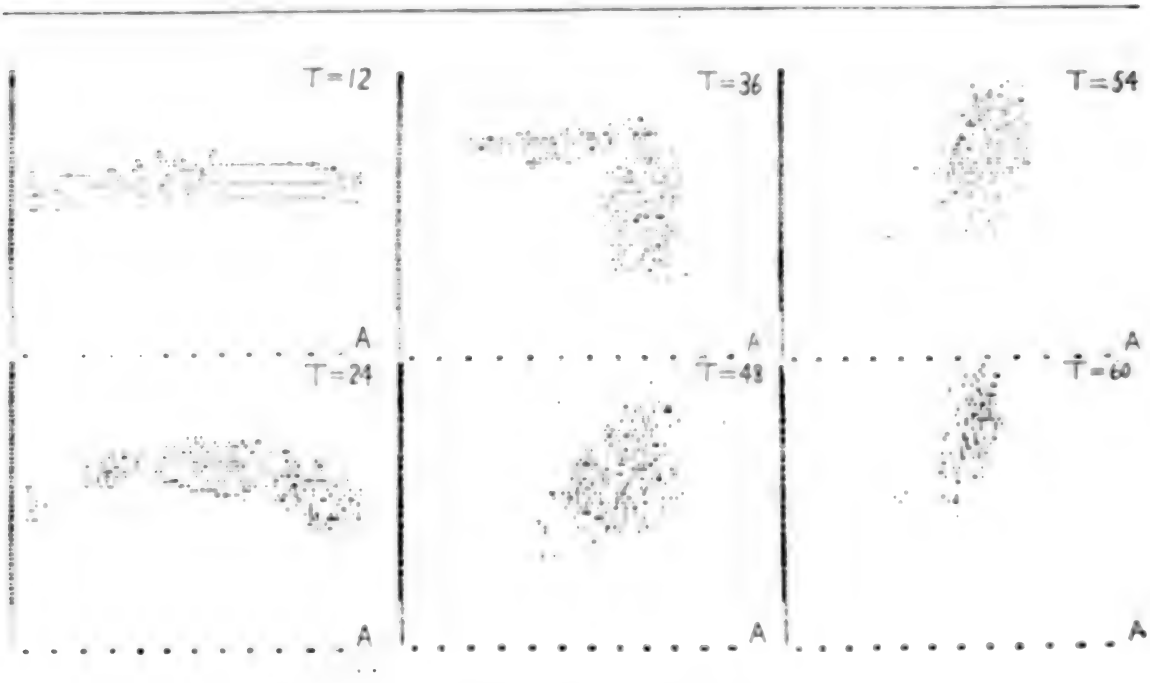


Figure 5. Computer Simulated Electron Cloud Pattern

3. Effect of Cut-off Zone Length.

Figure 6 shows the comparison of calculated results based on different cut-off length. The cut-off zone length is 63 mm for Curve 2, and 126 mm for Curve 4. Again, it indicates that when the total tube length is fixed, the longer the cut-off region is the lower the power output is.

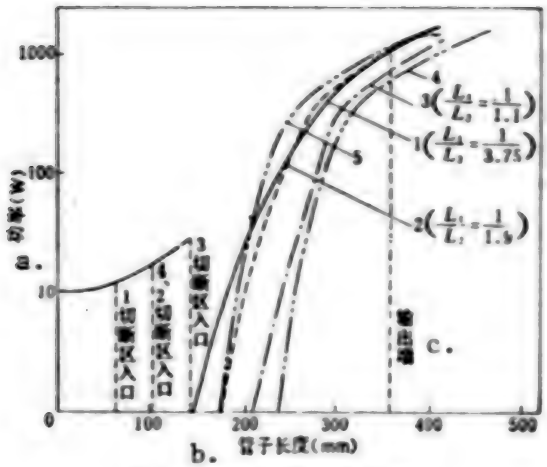


图 6 切割区长度和位置的影响

Figure 6. Effect of Tube Length and Sever Location

Key:

1. }
4,2. } cut-off zone entrance
3. }
a. power (W)
b. tube length (mm)
c. output end

Curve 5 was obtained by shifting Curve 4 laterally by 63 mm. Compared to Curve 2, we can see that the interaction beyond the cut-off zone is different. The un-saturated power output of Curve 5 is higher than that of Curve 2, which demonstrates that the longer the cut-off zone is, the more obvious the Diocotron effect on the electron cluster is. At least, this is true for a cut-off zone length up to 120 mm. As for a longer cut-off zone, we did not further calculate whether the Diocotron effect still favors the clustering of electrons.

4. Effect of Cut-off Zone Position.

The position of the cut-off zone is one of the problems of most concern in the design of high gain IBCFA devices. Figure 6 shows the comparison of calculated results obtained with a 63 mm long K-31 tube with its sever at different positions. Let the first gain length be L_1 and the second gain beyond the cut-off zone be L_2, then Curve 3 represents $L_1/L_2=1/1.1$ and $L_1=141.6$ mm. Curve 2 represents $L_1/L_2=1/1.9$ and $L_1=102$ mm. Curve 1 represents $L_1/L_2=1/3.75$ and $L_1=62.4$ mm.

From Figure 6 we can see that the power output of Curve 3 is always lower than those of Curves 1 and 2. This shows that it does not favor the power output if the sever is located in the middle of the tube ($L_1/L_2=1$). The reason is

very simple. The second gain section is too short to make a significant gain at the high frequency power output end.

Curves 1 and 2 basically coincide with each other in the 300 mm-400 mm range, which indicates that when the output end is located in this region, the cut-off zone entrance may be placed anywhere between 62.4 mm-102 mm without affecting the power output. If the output end is at 300 mm and L_1=102 mm, then L_1/L_2=1/1.3. If the output end is at 400 mm and L_1=62.4 mm, then L_1/L_2=1/4.4. To meet the requirements in power output and self-excited oscillation, it is more appropriate to have the sever placed at L_1/L_2=1/1.5 - 1/2.5 in a K-31 tube. The design of K-31 adopted L_1/L_2=1.9, which proves that the design is correct.

In addition, we can also see from the three calculated curves (1, 2 and 3) in Figure 6 that the high frequency power output is not yet saturated at 359.5 mm. From the cloud pattern at T=54 in Figure 5 that there are considerable electron clusters at the output end. If the output end is moved back 50-60 mm, a saturated power output may be attained. The electron cloud pattern at T=60 in Figure 5 also illustrates this point.

IV. Conclusions

1. The theoretical calculation is in good agreement with the experimental data, which shows that the physical model and mathematical description are essentially accurate.

2. The electron drift process in the cut-off zone has a significant effect on the clustering of electrons and the power output of the tube. This must be considered, especially when the sever is long.

3. When the total length of the tube is fixed, the insertion of a cut-off zone will shorten the slow wave line in the second gain section, which does not favor increased power output. Therefore, the cut-off length should be reduced as much as possible if isolation can be ensured.

4. The method can quantitatively investigate the effect of the position of the cut-off zone on the performance of the tube. Results indicate that the output of the K-31 tube may be moved backward by 50-60 mm if the position of the sever is properly designed.

The authors wish to thank Professors Wu Hongshi [0702 7703 6684] and Xu Chenghe [1776 2110 0735] for their beneficial instruction.

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APPLIED SCIENCES

NEW PLA, ITS OPTIMIZATION ALGORITHM FOR COMPUTER-AIDED DESIGN*

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 11 No 4, Jul 83 pp 52-60

[Article by Liu Chunhe [0491 2504 0735] of Harbin Institute of Technology]

[Text] Abstract: This paper presents a new type of PLA (R-PLA) which is made up of AND-EXCLUSIVE-OR arrays. The multi-channel digital networks described by vector Boolean algebra and the adders with parity check and parity prediction are realized very conveniently by using the R-PLA. The R-PLA is also simple for generating test codes of Boolean difference. This paper provides CAD algorithms for finding optimal or near-optimal ring sum cover.

I. Introduction

Hitherto, the ROM (read-only memory) and PLA (programmable logic array) in use were all made up of "AND-OR" array modules, so the implemented functions are the sum of products. The implemented functions just happen to be the sum with the least implications. This paper presents a new type of PLA module which is stronger in capability, and its internal structure is an "AND-EXCLUSIVE-OR" array. Since the operations of summing rings (EXCLUSIVE-OR) are more agile with the functional variations, the reflection of the functional change rate is more clear, consequently, they have attracted early attention of the specialists. The appearance of LSI and VLSI have enabled people to use vector Boolean algebra to describe the large scale multi-channel digital system network[4], and this paper shows that this type of PLA is the most convenient module for its implementation. An example from reference [4] shows its expression as below and its real value as in Table 1:

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* Paper received Jul 82, finalized Feb 83 [d. 11 Mar 83]

$$F(X_1, X_2) = (01)X_1^{\pi}(\widetilde{X}_1^{\pi})X_2^{\pi}(\widetilde{X}_2^{\pi}) + (11)X_1^{\pi}(\widetilde{X}_1^{\pi})X_2^{\pi}(\widetilde{X}_2^{\pi})$$
$$+ (10)X_1^{\pi}(\widetilde{X}_1^{\pi})X_2^{\pi}(\widetilde{X}_2^{\pi}) + (01)X_1^{\pi}(\widetilde{X}_1^{\pi})X_2^{\pi}(\widetilde{X}_2^{\pi})$$
$$= f_1 + f_2 + f_3 + f_4$$
$$= f_2 \oplus \bar{f}_1 f_4 \oplus \bar{f}_2 f_3 \bar{f}_4 \oplus f_1 \bar{f}_3 \bar{f}_4$$

where $f_1 = (01)X_1^{\pi}(\widetilde{X}_1^{\pi})X_2^{\pi}(\widetilde{X}_2^{\pi})$, $f_2 = (11)X_1^{\pi}(\widetilde{X}_1^{\pi})X_2^{\pi}(\widetilde{X}_2^{\pi})$, $f_3 = (01)X_1^{\pi}(\widetilde{X}_1^{\pi})X_2^{\pi}(\widetilde{X}_2^{\pi})$, $f_4 = (01)X_1^{\pi}(\widetilde{X}_1^{\pi})X_2^{\pi}(\widetilde{X}_2^{\pi})$, where $X' = X \oplus \bar{P}$, $P = (P_1, P_2, \cdots P_n)^*$, $\widetilde{X}^r$ is the rotation vector

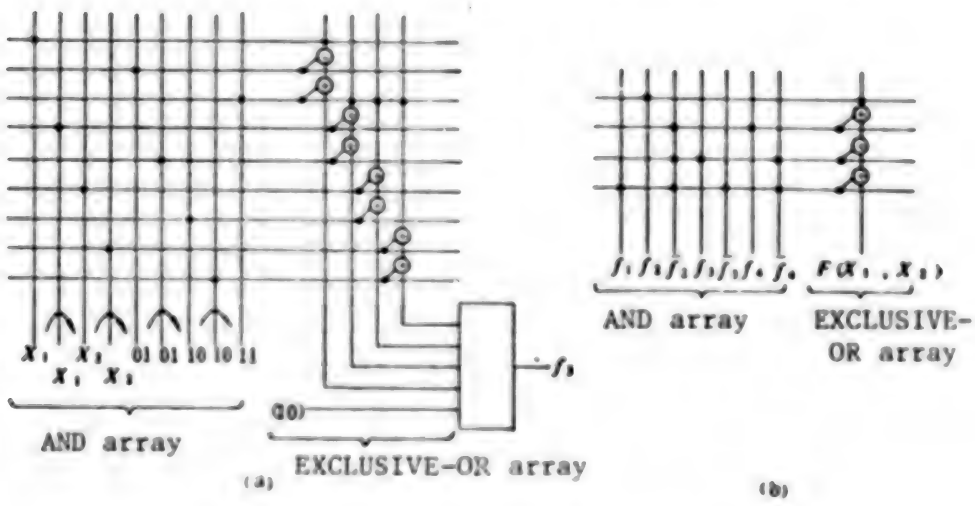


Fig. 1 $F(X_1, X_2)$ implemented by R-PLA

(a) f_5 (b) $F(X_1, X_2)$ ($\curvearrowright$ indicates rotation)

* n = 2 in this example.

Table 1. Real Values of Vector Boolean Functions

X_1	X_2	F
0 0	0 0	0 1
0 0	0 1	1 1
0 1	1 0	1 0
1 0	1 1	0 1
others		0 0

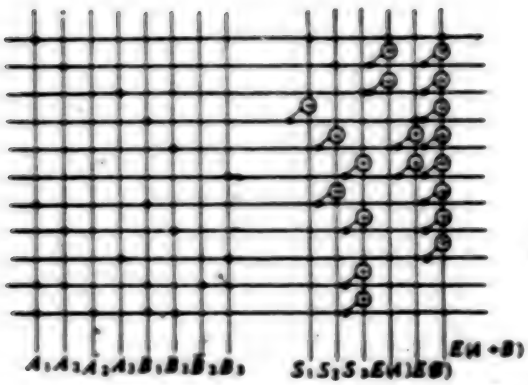


Fig. 2 Tri-bit Half-adder

Figure 1 shows the logic array diagram of the new type of PLA implementation presented in this paper. The figure shows only the vector expressions of f_3 (Fig. 1(a)) and $F(X_1, X_2)$ (Fig. 1(b)). Since this module is an expression of the ring sum implementation, it is called the R-PLA (ring programmable logic array).

With the R-PLA module it is very easy to implement the half-adder with parity-predicting fault tolerance capability. As shown in the tri-bit half-adder example in Fig.2, $A = (A_1A_2A_3)$ and $B = (B_1B_2B_3)$ are respectively the addend and augend, S_i is the i-th bit sum, and $E(X)$ is the parity of X.

II. Ring Sum Optimization Theory

Usually we define the 2^n states of the n variables of the combined function $f(x_1, x_2 \ldots, x_n)$ as an n-dimensional Boolean solid B_2n, so f expresses the sum of the products, i.e., the sum of the implication terms which collectively provide the covering for the 1-points of f on B_2n (and indeterminate points), and each implication term is a cube on B_2n. When f expresses the ring sum of the Reed-Muller expansion, it is indeed the new mapping relation. Therefore, the functional minimization theories of the past need to be suitably modified, and the mapping relationships amongst them need to be studied, and there is a need to set up some new concepts.

A Reed-Muller expansion of n variables has 2^n terms, let 1 be all its expansion coefficients, then the 2^n product terms (the constant term is called the term whose product is fixed at 1), form a collection of 2^n states. We define these 2^n states as an n-dimensional ring solid, designated as R_2n. We consider the mapping from Boolean solid B_2n to ring solid R_2n:

$$\varphi_1 \quad B_i \cdot \longrightarrow R_i \cdot$$

it is not hard to infer that

$$\varphi = \varphi \begin{pmatrix} 0 \longrightarrow \times \\ 1 \longrightarrow 1 \\ \times \longrightarrow 0 \end{pmatrix}$$

where 0 designates complement, 1 indicates the source variable, and X indicates that its variable is missing.

For example, a mapping relationship for 3-dimensional solids is shown in Figure 3.

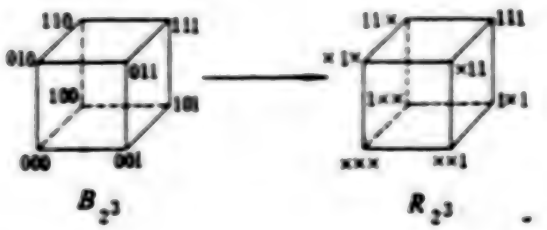


Fig. 3 The Mapping Between 3-dimensional Solids

Definition 1. The product of n variables is the smallest term, if and only if that product term is a point on R_{2^n}, designated as E_i, where i is the sum of the powers of "1" in E_i.

For example, $x_1x_4x_5$ = (1xx11), we set the power of the j-th variable of a product term of n variables to be 2^{n-j}, as the smallest ring term is $E_k = (a_1a_2\ldots a_n)$, $a_i \in \{1, x\}$, then for $E_k=(a_1a_2\cdots a_n)$, $a_i\in\{1, x\}$

$$k=a_1\cdot 2^{n-1}+a_2\cdot 2^{n-2}+\cdots+a_n\cdot 2^0$$

and where

$$a_i\cdot 2^{n-i}=\begin{cases} 0 & ,\text{if } a_i=x \\ 2^{n-i} & ,\text{if } a_i=1 \end{cases}$$

then $x_1x_4x_5 = E_{19}$.

The 1-point of function f is defined as the "1" product term of the coefficients of the Reed-Muller expansion on R_{2^n}. Conversely, the 0-point of f is the "0" product term of the coefficients in the Reed-Muller expansion. A point is called an odd-order point (whether it is a 1-point or a 0-point) when it is covered by an odd number of product terms, similarly, a point is called an even-order point if it is covered by an even number of product terms. Then, the so-called 1-point or 0-point, without any special explanation, speak of the odd order number. We know from Definition 1, the Reed-Muller expansion is the sum of rings of f (ring sum) of the smallest terms of function f.

Definition 2. By a simplest ring and its expression we mean: (1) the total number of variables in the expression is the least, and (2) there are the least number of operation symbols and rings in the expression. The numbers of the variables and operation symbols are called respectively the values of the ring and expression.

The function f(x) has changed from the sum of products into the ring sum, and for the standard type of functions, clearly

$$f(x)=\sum_{i\in I_1} m_i=\sum_{i\in I_1} m_i$$

where m_i is the smallest term of B_2n, I_1 is also the sample set of 1-points in B_2n, and $\sum$ is the ring sum $\oplus$

For the form of the set of the largest terms of f, we have

$$f(x)=\prod_{i\in I_0} M_i=\sum_{i\in I_1} m_i\oplus 1$$

where I_0 is the sample set of 0-points of B_2n.

For the more common conditions, there are the following theorems, but first we consider the next definition:

Definition 3. Let n be the power of ring of n variables

$$X^e=x_1^{e_1}\cdot x_2^{e_2}\cdots\cdots x_n^{e_n}$$

where $x_i^{e_i}=x_i+\bar{e}_i$, $e_i\in\{0,1\}$, $e=(e_1,e_2,\cdots\cdots,e_n)$.

Theorem 1. If function $f(x)=\sum_{i=1}^{m}P_i$, P_i is the product term, then the formula of its ring sum is $f(x)=\sum_{e} P^e$, $0<e<2^m-1$

where $P=(P_1,P_2,\cdots,P_m)=\prod P_i$.

Proof. It is obvious, using mathematical induction.

Definition 4. The intersection of two ring product terms $P_i=(a_{i1}a_{i2}\cdots a_{in})$ and $P_j=(b_{j1}\ b_{j2}\cdots b_{jn})$ is

$$P_i\cap P_j=\begin{cases} 0 \text{ if there is a k, such that } a_{ik}\cap b_{jk}=\phi_1 \\ (a_{i1}\cap b_{j1})(a_{i2}\cap b_{j2})\cdots(a_{in}\cap b_{jn}) \quad \text{others}\end{cases}$$

where the operator $\bigcap$ satisfies Table 2.

Table 2 $\cap$ table

$\cap$	b_{jk} 0	1	×
a_{ik} 0	0	1	×
a_{ik} 1	1	1	ϕ
a_{ik} ×	×	ϕ	×

Table 3 δ table

δ	b_{jk} 0	1	×
a_{ik} 0	0	×	1
a_{ik} 1	×	1	0
a_{ik} ×	1	0	×

Table 4 d table

d	b_{jk} 0	1	×
a_{ik} 0	ϕ	×	1
a_{ik} 1	ϕ	ϕ	Ω
a_{ik} ×	ϕ	Ω	ϕ

(0 means null)

Definition 5. The δ-operation of two ring product terms $P_i=(a_{i1}\ a_{i2}\cdots a_{in})$ and $P_j=(b_{j1}\ b_{j2}\cdots b_{jn})$ is

$$P_i\delta P_j=\begin{cases}(a_{i1}\ a_{i2}\cdots a_{ik-1}(a_{ik}\ \delta\ b_{jk})a_{ik+1}\cdots a_{in}) \\ \qquad \text{when there is only one k such that } a_{ik}\neq b_{jk} \\ P_i \text{ other conditions}\end{cases}$$

where the operator δ satisfies Table 3.

For example,

$P_i=(1101\times\times)$, $P_j=(\times 101\times\times)$, then $P_i\delta P_j=(1101\times\times)\,\delta\,(\times 101\times\times)=(0101\times\times)$, but $P_i\cap P_j=\phi$ (since when $k=1$, $1\cap\times=\phi$).

Definition 6. The d-operation of two ring product terms $P_i=(a_{i1}\ a_{i2}\cdots a_{in})$ and $P_j=(b_{j1}\ b_{j2}\cdots b_{jn})$ is

$$P_i dP_j=\begin{cases}P_i \text{ when there a k such that } a_{ik}db_{jk}=\Omega; \\ \phi \text{ for all k, such that } a_{ik}db_{jk}=\phi; \\ \{a_{i1}a_{i2}\cdots a_{ik-1}e_{ik}a_{ik+1}\cdots a_{in} \mid \text{such that there is only one k,} \\ \text{such that } a_{ik}=0, \text{ and } b_{ik}\neq 0\}; \\ \bigcup\{a_{i1}\ a_{i2}\cdots a_{is-1}\ b_{js}\ a_{is+1}\cdots a_{ik-1}e_{ik}a_{ik+1}\cdots a_{in} \mid \text{such that when there are} \\ \text{some S such that } a_{is}db_{js}=1 \text{ or when X, there is a k such that} \\ a_{ik}=0 \text{ and } b_{jk}\neq 0\}\end{cases}$$

where the operation symbol d satisfies Table 4. In Table 4, $a_{ik}\ d\ b_{jk}=e_{ik}$, $e_{ik}\in(1,x)$, and Ω are non-intersecting, and ϕ is null.

For example, P_i=(100 x 10), P_j = (00 xx 11)
when k = 1, 1d0 = ϕ; when k = 2, 0d0 = ϕ;
when k = 3, 0dX = 1, then $\{101 \text{ X } 11\}$.
When k = 4, XdX = ϕ, when k = 5, 1d1 = ϕ.
when k = 6, 0d1 = X, then $\{10 \text{ XX } 1 \text{ X}\}$. So, $P_i \not\delta P_j = \{101 \times 11,\ 10 \times \times 1 \times\}$.

From the aforementioned definition, the following basic properties can be inferred:

1. If $P_i \cap P_j = \phi$ and $P_i \ \delta \ P_j = P_s$, then $P_i \not\delta P_s = \phi$, $P_j \not\delta P_s = \phi$,
2. If $P_i \cap P_j \neq \phi$, and $P_i \ \delta \ P_j = P_s$ and $P_i \not\delta P_j = \phi$, then $P_s \not\delta P_j = \phi$,
3. If $P_i \ \delta \ P_j = P_s$ and $P_i \cap P_j \neq \phi$, then $P_i \not\delta P_j = P_s$,
4. $P_i \cap (P_j \ \delta \ P_s) = (P_i \cap P_j) \delta (P_i \cap P_s)$.

Definition 7. Ring product term P_j includes P_i, designated as $P_j \subseteq P_i$, if and only if $P_j \not\delta P_i = \phi$. if i $\neq$ j then it is a true inclusion, designated as $P_j \subset P_i$.

Definition 8. There exists 2^{n-i} different points on R_{2n} that may form a ringlet solid $T(2^{n-i})$ if and only if there are i identical variables in these 2^{n-1} points, where i $\in \{0,1,2,\ldots,n\}$, and especially when i=0, $T(2^n) = R_{2n}$; and when i=n, $T(2^0)$=E.

According to Definition 8, it is clear that, on R_2n, the dimension number of a solid is n-i, and according to Definition 5, each ringlet solid is a ring product term. Therefore, the number of "0" belonging to that product term is equal to the dimension number of its ringlet solid, and, furthermore, we can infer that for a m-dimensional solid $P_m \in R_i$, covering 2^m points, and P_m has at least m variables.

Definition 9. In a ringlet solid P_i, if the smallest term E_j is the largest vertex of P_i if and only if E_j is the largest point of the angular coordinate j covered by P_i. Similarly, there is a smallest vertex in P_i.

Lemma 1. On R_2n, the number of variables belonging to the sub-solid P_i is equal to the number of variables of the largest vertex of P_i.

Proof: Let E_j be the largest vertex of P_i, and $C(P_i)$ and $C(E_j)$ be respectively the values (the number of variables) of P_i and E_j.
First, consider P_i covering two points (2 points), then $P_i = E_j \not\delta E_k$.

Then if $C(P_i) > C(E_j)$, then E_j has at least one digit with an "X," and the corresponding digit of E_k is "1," then

Since E_j and E_k are neighboring points (with only one different point), then $C(E_j) < C(E_k)$, and this contradicts E_j being the largest point. If $C(P_i) < C(E_j)$, then $(1 \in E_j) \delta (X \in E_k) = (X \in P_i)$, and this contradicts the δ-operation. Next, consider P_i covering 2^2 points, and let P_n, P_s be two solids, without loss of generality, let P_r cover E_j, then from the foregoing proof we know that $C(P_r)=C(E_j)$, and if $P_r \delta P_s = P_i$, then,

$C(P_i) < C(P_r)$, with the following two possibilities:

(1) $(1 \in P_r) \delta (\phi \in P_s) = (X \in P_i)$, then $P_r \subset P_s$ and P_r, and P_s all contradict the 1-dimensionality hypothesis;

(2) $(0 \in P_r) \delta (1 \in P_s) = (X \in P_i)$, then $P_s \subset P_r$ and P_r and P_s all contradict the 1-dimensionality hypothesis.

Similarly we can infer up to 2_m points, Q.E.D.

Definition 10. On R_2n, if the product term P_i does not cover any odd degree 0-points and covering at least one odd degree 1-points then P_i is a ring implication term. If a product term P_i covers only even degree 0-points and not covering any odd degree 1-point, then it is an auxiliary term.

Definition 11. On R_2n, if P_i is an auxiliary implication term, then P_i is an auxilary implication term if and only if for any selected auxiliary implication term P_j, $P_j d P_j \neq \phi$ and $P_i d P_j \neq \phi$. P_i can be called an auxiliary term for short.

Definition 12. On R_2n, if P_i is an implication term, then P_i is a ring implication term if and only if under a certain selected covering no ring implication term P_j can be found, $j \neq i$, and without the condition of increasing any auxiliary implication terms, there is $P_i d P_j = \phi$.

For the same function f, if it can form different sets of ring implication terms under different covering conditions, will form a family of sets of ring implication terms. We give two covering selections of the same function in the following, as shown in Figure 4. In the selection of Figure f(a),

$P_1 = (\times 100) = x_2\bar{x}_3\bar{x}_4$, $P_2 = (0 \times 00) = \bar{x}_1\bar{x}_3\bar{x}_4$ are both ring implication terms;

$P_3 = (X01X) = \bar{x}_2 x_3$, $P_4 = (0XXX) = \bar{x}_1$ are both auxiliary implication terms; $P_5 = (XX01) = \bar{x}_3 x_4$ is a ring implication term; and $P_6 = (XXXX) = 1$ is an auxiliary implication term.

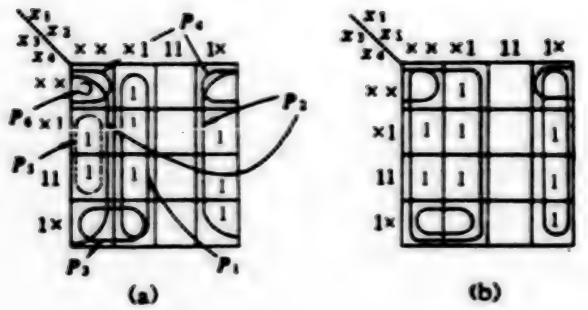


Fig. 4 Two Covering Selections

Lemma 2. If P_i is a ring implication term, then P_i has a number of variables no greater than the sum of the ring implication terms covered by P_i.

Proof. It comes naturally, following Lemma 1.

Lemma 3. In the family of sets of the ring implication terms of function f, the set with the least of the largest vertice is the optimal covering selection of the f-related operation symbol.

Proof. Obvious.

Theorem 2. In the family of sets of ring implication terms of function f, if S is the selection with the smallest number of variables, then S is also the least selection of operation symbol.

Proof. As S is the least selection of number of variables, there are three conditions:

(1) All of the largest vertices of S are 1-points (odd degree 1-point): If the largest vertices are not the smallest numbers, there will be at least one largest vertex which can be covered by the ring implication terms generated by another largest vertex. Also, as each largest vertex is a 1-point, there cannot be a point with larger value than the largest vertex of S, thus the number of the largest vertices can be decreased, hence violating the original assumption.

(2) All of the largest vertices are even degree 0-points: Since the values of these even degree 0-points are all greater than those other 1-points of the same ring implication terms, and, also, since the sum of the values of these even degree 0-points is the least, so, clearly, the number of the largest vertices is the least.

(3) There are odd degree 1-points and even degree 0-points in the largest vertices of S, then, by the synthesis of the two aforementioned conditions, the number of the largest vertices is the least. Q.E.D.

For a given function f, if we do not seek a complete family of sets of ring implication terms, but can directly find the smallest ring sum covering, it is still difficult to do this with computer-aided design (logic synthesis) under current conditions. However, we present a partition method in the following which may conveniently and easily find the quasi-smallest ring sum covering. Sometime, the obtained result is indeed the smallest ring sum covering.

Definition 13. On R_2n, if P_i is a ring implication term, if P_i is a partitioning term of the ring implication term (called the partitioning term for short) if and only if (1) P_i does not cover any 0-points; (2) any odd degree 1-point covered by P_i is not again covered by any other ring implication terms; and (3) $P_i d P_j \neq \emptyset$ for any ring implication terms not covering any 0-points.

For clarification, we take the function shown in Figure 4 and use the partitioning term to express it, as shown in Figure 5. We express function f as the ring sum of the partitioned terms, and this method is the partitioning method. The optimal partitioning is the one which obtain the least value of the function.

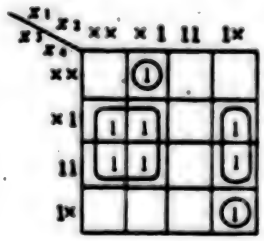
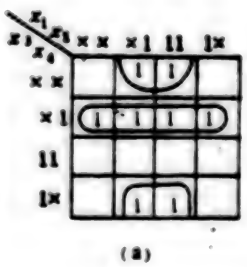
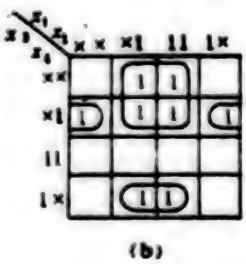


Fig. 5 Partitioning term of f



(a)



(b)

Fig. 6 Partitioning selection

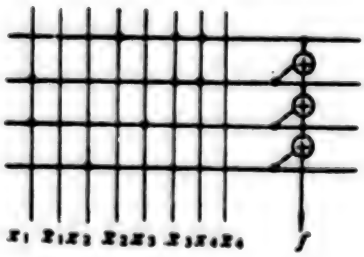


Fig. 7 R-PLA circuit of $f(x_1,x_2,x_3,x_4)$

Definition 14. In the 1-point set of f, the points which are not covered by the ring implication terms called scattered points, the greatest scattered point is the one with greatest number of variables.

Treating the conclusions of Theorem 2 with the partitioning method, we have the following theorem.

Theorem 3. For function f, the partitioning covering selection of the least number of variables is also the best partitioning covering selection of the operation symbol.

In order to find the covering selection of the least number of variables, we present the following partitioning methods.

Method 1.

(1) First, take each direction of the greatest scattered point to form a partitioning selection;

(2) Repeat step (1) for each largest scattered point;

(3) Form a complete family of sets of partitioning covering, make the selection among the one with the smallest number of variables.

Example: $f(x_1, x_2, x_3, x_4) = \sum_{i=8}(E_1, E_4, E_5, E_6, E_9, E_{12}, E_{13}, E_{14})$.

The starting greatest scattered points are E_{14}, E_{13}, take either one, say E_{14}, to find a partitioning covering selection as shown in Figure 6(a), and E_{13} has only one direction to find the partitioning term. Then use E_{13} to find the partitioning term. E_{13} has two directions in which to find the partitioning term, one of which has the same direction to set the partitioning selection as in Figure 6(a), and the other as shown in Figure 6(b). Other covering selections obtained through the greatest scattered points are the same as those in Figure 6(a) and 6(b). So, the final partitioning covering family of sets are

$$\{\{010\times,\ 00\times 1\},\ \{01\times 0,\ 011\times, 0\times\times 1\}\},$$

Clearly, (a) given the best partitioning, since the sum of its variables is 6, and its total of symbols is 1, as $f(x_1, x_2, x_3, x_4) = \bar{x}_1 x_2 \bar{x}_3 \oplus \bar{x}_1 \bar{x}_2 x_4$.

However, as the ordinal initial functions are obtained from the truth tables, so, the form of the function as the sum of the smallest terms, clearly, Method 1 cannot be directly used; the smallest terms need to be converted into the smallest ring term. The following gives a function expressible as the sum of arbitrary product terms (including smallest terms), to find its optimal or near optimal computer-aided design (logic synthesis) of partitioning computation method.

Method 2

(1) Convert the product terms of the form of the product sum of the function into the ring product terms, this forms the set Z of product terms;

(2) Complete the δ-operation of any two product terms which are δ-operable, then designate by symbol ($\surd$), until those product terms without the $\surd$ symbol cannot be operated on by the δ-operation;

(3) Mutually carry out d-operations on any two product terms (including the results of their operations), then designate by $\overset{\vee}{}$, until those product terms without the $\overset{\vee}{}$ symbol cannot be operated by d-operation. Those product terms without $\overset{\vee}{}$ symbol are members of the set of the smallest or quasi-smallest partitioning terms.

Example. The set of smallest terms of $f(x_1, x_2, x_3, x_4)$ is

$$Z=\{\overset{\vee}{0}100,\ 1100,\ 0001,\ \overset{\vee}{0}101,\ \overset{\vee}{0}111,\ \overset{\vee}{1}011,\ \overset{\vee}{0}110,\overset{\vee}{1}010\}$$

1. Carry out δ-operations on Z:

$$(0100)\delta(0101)=(010\times)$$
$$(0111)\delta(0110)=(011\times)$$
$$(1011)\delta(1010)=(101\times)$$

combining the results of those without $\vee$ symbol and δ-operation, this form a new set

$$Z'=\{\overset{\vee}{1}100,\ \overset{\vee}{0}001,\ \overset{\vee}{0}10\times,\overset{\vee}{0}11\times,\ \overset{\vee}{1}01\times\}$$

2. Carry out d-operations on Z^*:

$$(1100)\delta(0001)=\{\overset{\vee}{1}10\times\}$$
$$(0001)\delta(1100)=\{\times001,1\times01\}$$
$$(010\times)\delta(011\times)=\{01\overset{\vee}{\times}\times\}$$
$$(011\times)\delta(010\times)=\{\phi\},\ \text{likewise}$$
$$(110\times)\delta(101\times)=\{11\overset{\vee}{\times}\times\}$$
$$(101\times)\delta(110\times)=\{1\times1\times\}$$
$$(01\times\times)\delta(11\times\times)=\{\times1\times\times\}$$

so $\{\times001,\ 1\times01,\ 1\times1\times,\ \times1\times\times\}$ is the optimal partitioning cover for $f(x_1, x_2, x_3, x_4)$, the implementing wiring is as shown in Figure 7.

According to the concepts introduced above, other algorithms can be deduced. Due to the limitation of space, they are not discussed.

III. Conclusions

This "AND-EXCLUSIVE-OR" array type of modules possess very strong capabilities. Besides implementing the large scale multi-channel digital system networks and implementing very strong capabilities of parity check or parity prediction, etc., fault tolerance technoques, they can also be conveniently implemented in the arithmetic or control units of computers. Consequently, this new type of PLA has a bright future implementing standardization and normalization of computer devices. Specifically, this new type of PLA has another strength, it makes the generation of error diagnostic test code much easier.

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APPLIED SCIENCES

ACCURATE COMPUTER-AIDED DESIGN OF MMIC BROAD-BAND FET AMPLIFIERS*

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[Text] Abstract: A computer-aided design procedure applicable to low-noise and broad-band MMIC FET, amplifiers is presented. The method takes into account the non-unilateral behavior of the FET, losses in the matching networks and complex termination mismatches. The design procedure is more complete and accurate than currently available CAD methods. Two design examples, an 8 ~12 GHz and a 6 ~15GHz MMIC FET amplifier, are presented to illustrate the applications.

I. Design Considerations

In recent years, GaAs microwave monolithic integrated circuits (MMIC) have attracted more and more attention, and may develop into a new generation of microwave component with mass production[1-3]. Therefore, a suitable computer-aided precision design procedure is very much needed.

Currently, the design procedures for microwave diodes and FET amplifiers are all based on scattering parameters of transistors, and the amplifiers are designed according to lossless matching network unit termination resistance (matching terminations)[4-14]. In most of these types of designs, the so-called $|S_{12}| = 0$ (unilateral design), the non-unilateral characteristics of the transistors are neglected[3-12], consequently, some errors are introduced in the design of transistors with large S_{12} values. For example, in the design of transistors with $|S_{12}| = 0.08 \sim 0.1$, assuming $|S_{12}| = 0$, then the transmission gain error is 0.6 ~2.5dB, and the shape of the response curve is changed. (See Figure 1). Also, the components in the matching network suffer some losses. Neglecting these losses, especially when the frequencies are

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higher, will also introduce errors. For example, after taking into account the losses in the various matching networks in a design of a unilateral lossless network, the transmission gain will decrease by 1.5 ~2.5dB, and the shape of the response curve will also change somewhat. Therefore, in the unilateral design according to lossless matching network the difference between design gain and actual gain may reach 4.4dB. (See Figure 1)

At the MMIC termination, there is usually some parasitic capacitance and even parasitic inductance. Consequently, it is hard to achieve a perfect matching network for the MMIC amplifiers. In a minimax gain design according to the unit termination resistance (in accordance with lossy non-unilateral design), the two ends are both connected with 0.05pF parasitic capacitors and 50 Ω termination resistors, then the noise coefficients will increase by 0.15dB, and gains will change by 0.1 ~1.3dB. More importantly, the gain response is no longer a minimax response. (See Figure 2). Therefore, we have studied a more complete and more precise design method for MMIC FET amplifiers. This method takes into account the FET non-unilateral characteristics, matching network losses, and the effects of the complex termination mismatch on amplifier characteristics.

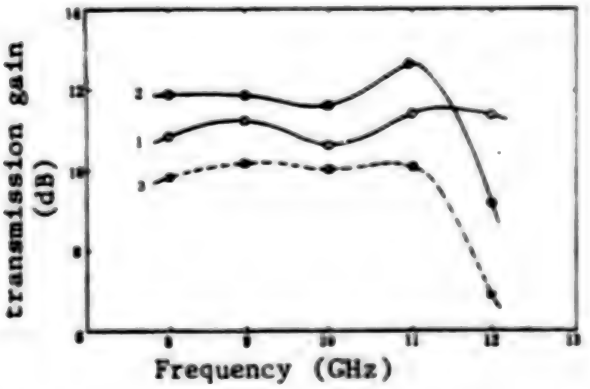


Fig. 1 FET Non-unilateral Characteristics and the Effect of Network Loss on the Amplifier Gain (TRW 0.5 μm FET)

Curve 1 unilateral design ($|S_{12}| = 0$), lossless network

Curve 2 Same amplifier, effect of $|S_{12}| \neq 0$

Curve 3 Same amplifier, effects of $|S_{12}| \neq 0$ and network loss

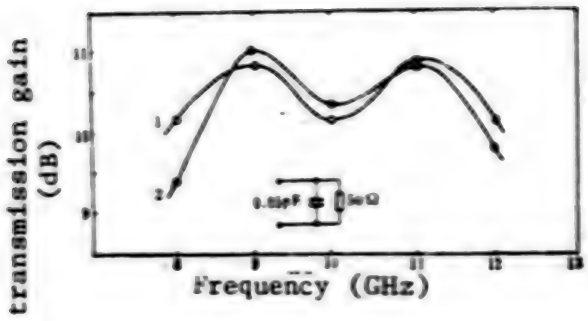


Fig. 2 Comparison of Matching Termination and Complex Termination Amplifier (non-unilateral simultaneous design, lossy network, TRW 0.5 μm FET)

Key:
1. Matching termination
2. Complex termination

II. Transmission Gains

When a solid state microwave amplifier has a lossy matching network, and the signal source and load admittance are complex (see Figure 3), then the general formula of transmission gain may be expressed as

$$G_T = \frac{(1-|\rho_g|^2)}{(1-|S_{in}|^2)} \frac{|S_{in}|^2}{(1-|S'_{in}|^2)} \frac{(1-|\rho_i|^2)}{(1-|S_{rn}|^2)} |S_{rn}|^2 \cdot \frac{(1-|\rho_j|^2)}{(1-|S'_{rn}|^2)} \frac{|S_{on}|^2}{(1-|S_{on}|^2)} \frac{(1-|\rho_l|^2)}{(1-|S'_{ok}|^2)} = G_{gi} \cdot G_{ii} \cdot G_{it} \cdot G_{tt} \cdot G_{to} \cdot G_{oo} \cdot G_{ol} \quad (1)$$

where G_{gi} and G_{ol} are respectively signal source and load matching gain; G_{ii} and G_{oo} are respectively input and output matching networks (NI and NO) loss attentuations; G_{it} and G_{to} are respectively FET input and output matching gain; and G_{tt} is the fixed FET gain.

$$G_{g1}=\frac{1-|\rho_g|^2}{1-|S_{rn}|^2}= \quad \frac{\text{Incidence power of } I_1 \text{ to NI}}{\text{available power at signal source}} \tag{2a}$$

$$G_{11}=\frac{|S_{rn}|^2}{1-|S'_{rn}|^2}= \quad \frac{\text{Available power at } T_1}{\text{incidence power of } I_1 \text{ to NI}} \tag{2b}$$

$$G_{12}=\frac{1-|\rho_1|^2}{1-|S_{rn}|^2}= \quad \frac{\text{Incidence power from } T_1 \text{ to FET}}{\text{available power at } T_1} \tag{2c}$$

$$G_{22}=|S_{rn}|^2= \quad \frac{\text{FET transmitted power at } T_2}{\text{Incidence power from } T_1 \text{ to FET}} \tag{2d}$$

$$G_{02}=\frac{1-|\rho_2|^2}{1-|S'_{rn}|^2}= \quad \frac{\text{Power absorbed by NO at } T_2}{\text{FET transmitted power at } T_2} \tag{2e}$$

$$G_{00}=\frac{|S_{on}|^2}{1-|S_{on}|^2}= \quad \frac{\text{NO transmitted power at } O_2}{\text{Power absorbed by NO at } T_2} \tag{2f}$$

$$G_{01}=\frac{1-|\rho_l|^2}{1-|S'_{on}|^2}= \quad \frac{\text{Power absorbed by load}}{\text{Power absorbed by NO at } O_2} \tag{2g}$$

The normalized complex reflectivity coefficient is

$$\rho_k=(Y'^{*}_i-\dot{Y}_i)/(\dot{Y}'_i+\dot{Y}_i) \tag{3}$$

where k = g, 1,2,1; i = g, I2, T2, 02; j = I1, T1, 01, 1; $\dot{Y}'_i$ is a unit normalized output admittance of a certain link when the entire fixed link is as shown in Figure 3. $\dot{Y}'^{*}_i$ is its conjugate complex number; $\dot{Y}'_j$ is the unit normalized input admittance of the next link when its output termination is the unit resistance.

$$\dot{Y}'_i=\frac{1-S'_m}{1+S'_m} \qquad \dot{Y}_i=\frac{1-S_m}{1+S_m}$$

where m = g, I22, 022 (Y'_g=$\dot{Y}_g$, S'_g=S_g); N=I11, T11, 011, ℓ.

All of S_{Iij}, S_{oij} and S_{Tij} (i,j=1,2) correspond to NI, NO and the FET scattering parameter, but S_{I22}, S_{T22} are the NI, FET and NO unit normalized output reflectivity coefficients of the last link shown on Figure 3.

$$S'_{in}=S_{in}+\frac{S_{in}\cdot S_{in}\cdot S'_{in}}{1-S_{in}\cdot S'_{in}} \qquad (4)$$

where ℓ = I, T, O; f = g, I, T ($S'_{g22} = S_g$).

Equation (1) is the most generalized formula for calculating the transmission gain of a solid state microwave amplifier, and it may be simplified to compute transmission gain under any special condition.

Under the conditions of a single signal source and load admittance, $Y_g = 1$, $Y_\ell = 1$, but $G_{gi} = 1$, and $G_{o\ell} = 1$, we can obtain

$$G_T=G_{i1}\cdot G_{11}\cdot G_{12}\cdot G_{2i}\cdot G_{2o} \qquad (5)$$

When the amplifier is designed with lossless matching network, $G_{ii} = 1$, $G_{oo} = 1$, then

$$G_T=G_{11}\cdot G_{12}\cdot G_{2i}=\frac{(1-|\rho_1|^2)}{(1-|S_{rm}|^2)}\cdot|S_{rm}|^2\cdot\frac{(1-|\rho_2|^2)}{(1-|S'_{rm}|^2)} \qquad (6)$$

This equation yields the same results as those obtained by Carlin and Komiak[13], and we call it the non-unilateral design formula. When $|S_{T12}| \ll 1$, i.e., neglegible, then the unilateral design formula may be obtained:

$$G_T=\frac{(1-|\rho_1|^2)}{(1-|S_{rm}|^2)}\cdot|S_{rm}|^2\cdot\frac{(1-|\rho_2|^2)}{(1-|S_{rm}|^2)} \qquad (7)$$

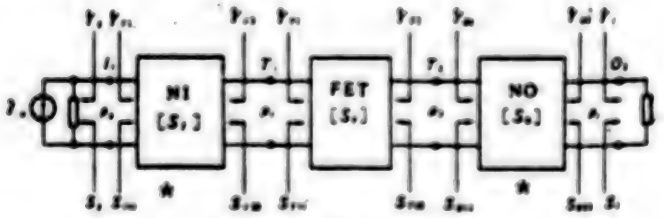


Fig. 3 An FET Amplifier Possessing Lossy Matching Network and Complex Termination Admittance

III. Noise Measures

The FET amplifier noise coefficient is[17,18]

$$F_N=F_{min}+4R_n\frac{|S'_{in}-S_g|^2}{|1+S_g|^2(1-|S'_{in}|^2)} \qquad (8)$$

where F_{min} is the least FET noise coefficient, R_F is the unit normalized noise resistance of the FET, S_F is the optimal unit normalized noise reflectivity coefficient, $S_F = (1 - Y_F) / (1 + Y_F)$, and Y_F is the optimal unit normalized noise admittance of the FET.

For the first stage design of a low noise amplifier, the noise measure M_N can be used as a design criterion, it has also included the effects of noise coefficient and transmission gain G_T.

$$M_N = \frac{F_N - 1}{1 - 1/G_T} \tag{9}$$

For a two-stage amplifier, its total noise coefficient is

$$F_{N,} = F_{N1} + \frac{F_{N2} - 1}{G_{T1}} \tag{10}$$

where F_{N1} and F_{N2} are respectively the noise coefficient of the first and second stage, and G_{T1} is the transmission gain of the first stage. When the first stage of the amplifier is designed according to the smallest noise measure, the total noise coefficient F_{Nt} is the smallest.

IV. Lossy Matching Network

In order to conserve the area occupied on the substrate, we use the lumped elements to build the matching network. In the microwave lumped elements, all of the losses will vary with the $\neq$ frequencies[1,2,20,21]. In the industance, including those in the band inductance and coiled inductance, or in the interweaving capacitance, the losses are skin losses, and they are proportional to the square foot of the frequency. In the metal-insulator-metal (MIM) inductance, there is a dielectric loss besides skin loss, and it is inversely proportional to the frequency.

Using a series equivalent circuit (see Figure 4), we have obtained the impedance of a lumped element:

$$\left.\begin{aligned} Z_L &= (\sigma_L \omega^{1/2} + j\omega) L \\ Z_C &= \left(\frac{\omega^{1/2}}{\sigma_c} - j\frac{1}{\omega}\right)\frac{1}{C} \\ Z_{Cd} &= \left[\left(\frac{\omega^{1/2}}{\sigma_c} + \frac{1}{\sigma_d \omega}\right) - j\frac{1}{\omega}\right]\frac{1}{C} \end{aligned}\right\} \tag{11}$$

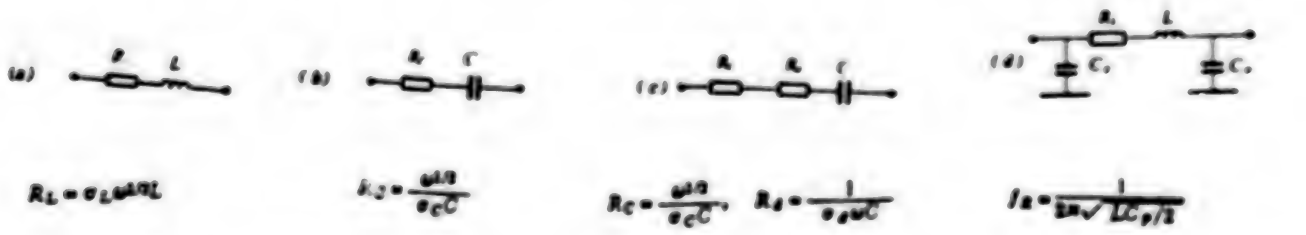
where Z_L, Z_C, Z_{Cd} are respectively the resistances to inductance, interweaving capacitance, and MIM capacitance. σ_L, σ_c and σ_d are constants, and they may be determined by the quality factor test value Q_T under certain normalized test frequency ω_T:

$$\sigma_L = \frac{\omega_T^{1/2}}{Q_{LT}},\quad \sigma_C = \omega_T^{1/2} \cdot Q_{CT},\quad \sigma_d = Q_{dT}$$

where Q_{LT} is the test value of inductance Q_T, Q_{CT} and Q_{dT} are respectively Q_T test values caused by skin loss and dielectric loss in the capacitance. The total Q_T value in the MIM capacitance can be determined as the following:

$$\frac{1}{Q_T} = \frac{1}{Q_{CT}} + \frac{1}{Q_{dT}} \qquad (12)$$

It should be noted, there may exist parallel ground capacitance C_p in the inductance (Figure 4d), and it may form a resonance with inductance L, and its frequency is[2]: $f_R = 1/2\pi\sqrt{LC_p/2}$. When the working frequency is near this resonant frequency in value, the test value Q_{LT} suffers a noticeable decrease. Therefore, in order to decrease the effect of parallel capacitance, one should ensure that $f_R \geq (2.5 \sim 3) f_u$ when designing a capacitance element, f_u is the upper limit of the working frequency.



(a) inductor (b) interweaving capacitor (c) MIM capacitor (d) inductor w. ground capacitance

Fig. 4 Equivalent Circuit of Microwave Lumped Element

V. Computer-aided Design Method

We have studied a computer-aided design method for a non-unilateral design of an MMIC FET amplifier with a lossy matching network and its two terminations having complex admittances.

The main program AMDI-OPTS is a multivariate constrained search method using a simplex domain algorithm[22,23]. After the designer has selected a suitable topology for the matching network and has given initial values for its elements, this program can calculate the transmission gains, noise coefficients, and noise measure for the amplifier. It can also use the minimax transmission gain[16] in the bandpass or the minimax noise measure as the objective function to search for the optimal value for the lossy element (inductance or capacitance) and to individually use the parametric conversion method and penalty method to satisfy the following constraints:

$$\left.\begin{aligned} &a_i \le x_i \le b_i \qquad (i=1,2,\cdots,n) \\ &|S_i' \cdot S_{in}'| < 1 \qquad (j=1,2;\ k=122,011) \end{aligned}\right\} \tag{13}$$

to ensure the element values can be realized within a given region (a_i, b_i are the lower and upper limits of the element values) and the stability of the FET input and output terminations.

Program AMDI-OPTS can also be used simultaneously to search for the optimal values of each element of the input and output matching network. Using this non-unilateral simultaneous design method, we can improve the results obtained from the individual designs of input and output networks. The computation results show that this kind of simultaneous method is suitable for designing the broad-band minimax gain (Figure 5) and minimax noise measure (Figure 6). This program can also be easily used to design the MMIC FET amplifiers with lossy or lossless matching networks and unit or complex termination admittance, taking into account various conditions of unilateral or non-unilateral properties.

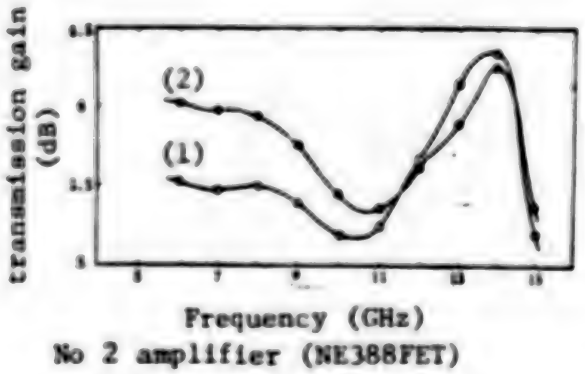
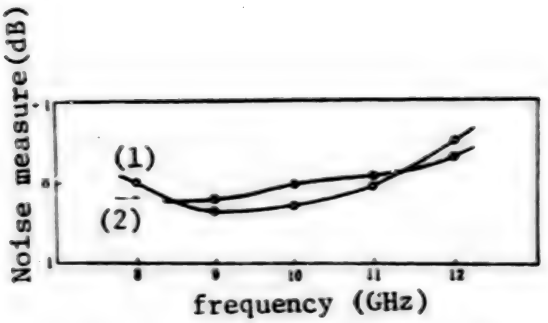


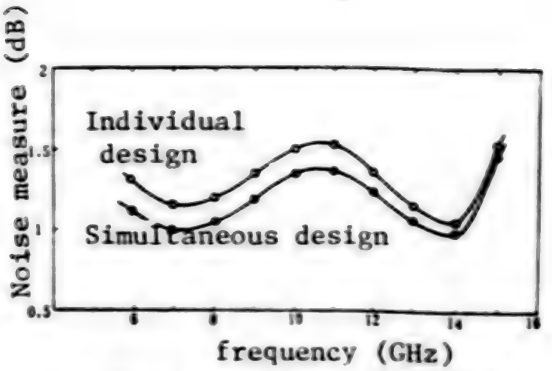
Fig. 5 Comparison of Non-unilateral Individual and Simultaneous Designs (lossy network, matching termination)

Key:
1. Individual design
2. Simultaneous design

In order to obtain the initial value of each element, we have used a computer-aided design program for any microwave solid state amplifier with lossless network and unilateral matching termination. We have frequently used a kind of simplified real frequency technique[25].



(a) No 1 amplifier (TRWO.5um FET)



(b) No 2 amplifier (NE388FET) minimax noise estimator design

Fig. 6 Comparison Non-unilateral Individual and Simultaneous Designs (lossy network, matching termination)

VI. Actual Design Examples

This paper introduces the results of two kinds of MMIC FET amplifiers, and each one is designed according to the minimum value of the gain in the bandpass being at maximum (minimax gain) or the maximum value of the noise measure in the bandpass being at minimum (minimum-maximum noise measure).

Fig. 7 No 1 Amplifier Wiring Diagram

Table 1. Initial Value of the Elements of No 1 Amplifier (Q = 30, Q = 50, 12GHz)

parameter / design format	R_g(Ω)	C_g(pF)	C_1(pF)	L_1(nH)	L_2(nH)	L_3(nH)
minimax gain design	50	0.05	0.8098	0.1830	0.4337	0.4180
minimax noise measure design	50	0.05	0.3154	0.3172	0.4486	0.2489

parameter / design format	C_3(pF)	R_f(Ω)	C_f(pF)	C_2(pF)	L_4(nH)	L_5(nH)	L_6(nH)
minimax gain design	0.1130	50	0.05	0.1158	1.5489	1.0487	1.5939
minimax noise measure design	0.0945	50	0.05	0.1255	2.7589	1.7405	1.1179

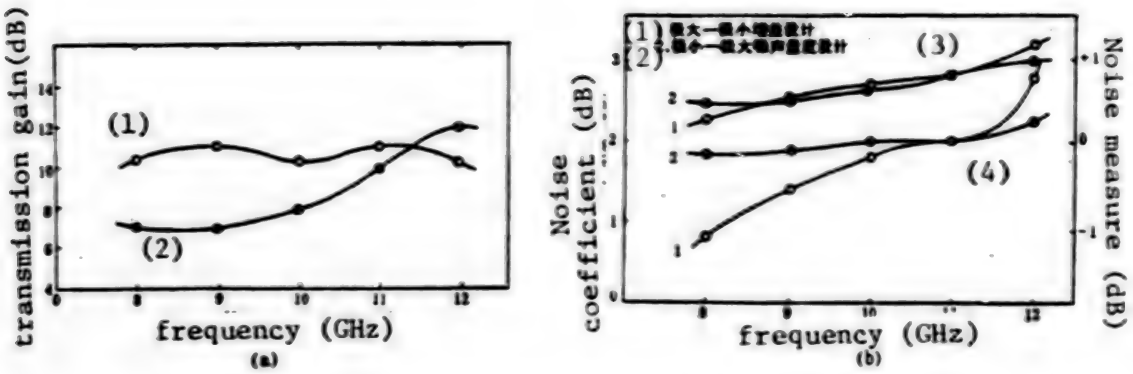


Fig. 8 Transmission gain, noise coefficients, and noise measures of No 1 amplifier

Key:

1. Maximum-minimum gain design
2. Minimax noise measure design
3. Noise coefficient
4. Noise measure

(1) The No 1 amplifier is an 8～12GHz TRW 0.5 μm FET monolithic microwave integrated amplifier, its wiring diagram is shown in Figure 7, and the values of its values are shown in Table 1. According to minimax gain design, the bandpass gain is 10.56±0.38dB; and according to the minimum-maximum noise estimator design the obtained bandpass noise is 0.60±23dB (see Figure 8).

(2) The No 2 amplifier is a 6～15GHz NE388 FET[26] monolithic microwave integrated amplifier, and its matching network wiring diagram is shown in Figure 9 and the values of its elements are shown in Table 2. According to the bandpass gain of 5.71±0.37dB obtained in the minimax gain design, and according to minimum-maximum noise estimator the obtained bandpass noise is 1.10±0.25dB. (See Figure 10).

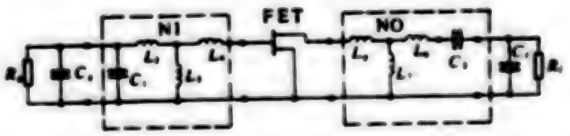


Fig. 9 No 2 Amplifier Wiring Diagram

Under the aforementioned situations, the amplifiers are all designed under the conditions of lossy lumped element matching network and signal source, and the load admittances are all complex numbers, and at 12GHz the quality factor test values are set at Q_{LT} = 30, Q_{CT} = 50. The complex admittances of the two terminations are both associated with the 0.05pF parasitic capacitance and 50Ω termination resistance. The inherent slanting decrease property of gain in the FET device has been considered in the design.

Table 2. The Values of No 2 Amplifier Elements (Q = 30, A = 50, 12GHz)

parameter / design format	R_g(Ω)	C_g(pF)	C_1(pF)	L_g(nH)	L_s(nH)	L_d(nH)
minimax gain design	50	0.05	0.1214	0.5858	2.7168	0.0453
minimax noise measure design	50	0.05	0.1404	0.6292	2.8374	0.0407
parameter / design format	R_l(Ω)	C_l(pF)	C_2(pF)	L_g(nH)	L_1(nH)	L_2(nH)
minimax gain design	50	0.05	0.1404	0.6292	2.8374	0.0407
minimax noise measure design	50	0.05	0.8400	0.2750	1.3023	0.3110

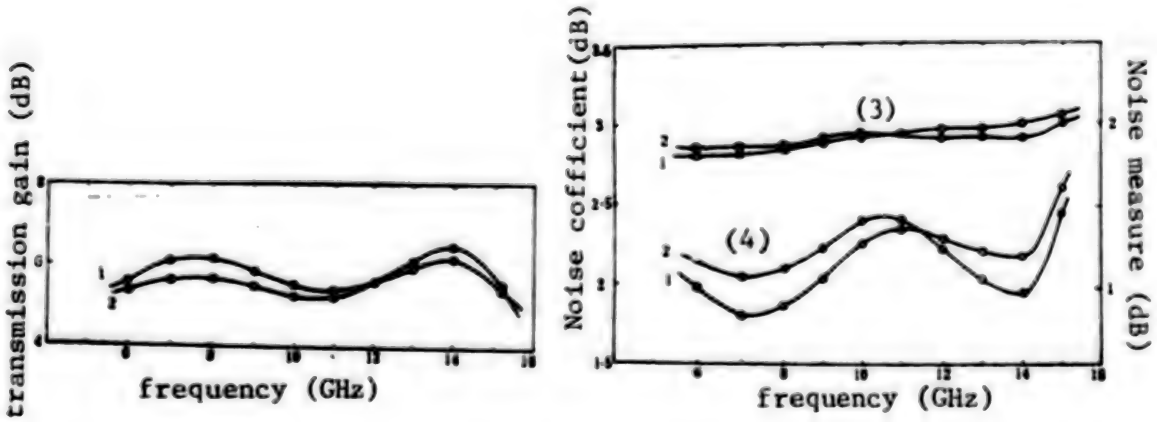


Fig. 10 Transmission Gain, Noise Coefficients, and Noise Measure of No 2 Amplifier

Key:

1. Maximum-minimum gain design
2. Minimum-maximum noise measure design
3. Noise coefficient
4. Noise measure

VII. Conclusions

The new computer-aided design procedure introduced in this paper has already been successfully used in designing lossy matching network and complex termination admittance noise and broad-band MMIC FET amplifiers. This method has taken into account the non-unilateral property, the loss associated with matching network frequency, and the complex numbers mismatch of the terminations of a FET. Therefore, it is more complete and precise than the other computer-aided design methods currently in use.

This kind of input and output matching network non-unilateral simultaneous design procedure has been illustrated by several actual design examples: it is suitable for use on design of minimum-maximum noise estimator and broadband minimax transmission gain measurement.

This technique can also be developed to design multi-stage MMIC FET amplifiers with lossy network and complex termination admittance, and for other types of microwave solid state amplifiers.

[APPENDIX] Derivation of the General Formula for Transmission Gain

Let a unit resistance be connected to the output termination of NI (port T_1, see Figure 3), i.e., $Y_{T1} = 1$, $S_{T11} = 0$. The power absorbed by NI at port I_1 is:

$$P_{I_1 \cdot T_1} = P_{av.s}(1-|\rho_s|^2) \qquad (A)$$

where $P_{av.s}$ is the available power of the information source, $\rho_s = (Y_s^* - Y_{I1})/(Y_s^* + Y_{I1})$, $Y_{I1} = (1-S_{I11})/(1+S_{I11})$. The power transmitted by NI at port I_1 is:

$$P_{I_1 \cdot T_1} = P_{av.s}(1-|\rho_s|^2)\frac{|S_{I21}|^2}{(1-|S_{I22}|^2)} \qquad (B)$$

Then, connect the next FET link, let a unit resistance be connected to the FET's output termination (port T_2) Treat all of the links before port I_1 as an equivalent power source, the available power at port T_1 is:

$$P_{av \cdot T_1} = \frac{P_{I_1 \cdot T_1}}{(1-|S'_{I22}|^2)} \qquad (C)$$

where S'_{I22} is the normalized unit output reflectivity coefficient of this equivalent power.

$$S'_{I22} = S_{I22} + \frac{S_{I21} \cdot S_{I12} \cdot S_s}{1 - S_{I11} \cdot S_s}$$

The power transmitted by FET at port T_2 is:

$$P_{I_1 \cdot T_2} = P_{av \cdot T_1}(1-|\rho_1|^2)\frac{|S_{T21}|^2}{(1-|S_{T22}|^2)} \qquad (D)$$

where P_1 is the complex normalized reflectivity coefficient.

$$\rho_1 = \frac{Y'^*_{I1} - Y_{T1}}{Y'_{I1} + Y_{T1}}, \quad Y'_{I1} = \frac{1-S'_{I22}}{1+S_{I11}}, \quad Y_{T1} = \frac{1-S_{T11}}{1+S_{T11}}$$

Substituting (B) and (C) into (D), we get

$$P_{I_1 \cdot T_2} = P_{av \cdot s}\frac{(1-|\rho_s|^2)}{(1-|S_{I11}|^2)}\ \frac{|S_{I21}|^2}{(1-|S'_{I22}|^2)}\ \frac{(1-|\rho_1|^2)}{(1-|S_{T11}|^2)}|S_{T21}|^2 \qquad (E)$$

Using the same procedure on the following links, we can eventually obtain the ratio of the power of the amplifier transmission gain absorbed by the load and the signal source power, that is the general formula (1).

We thank Prof. Walter H. Ku of Cornell University for the useful discussion on some of the problems on this paper.

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APPLIED SCIENCES

ELECTRONSTATIC LENS OF NEW TYPE FIELD EMISSION GUN

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 12, No 1, Jan 84, pp 119-121

[Article by Tu Yushan [1458 5124 0810] of the Institute of Electronics, Chinese Academy of Sciences: "Characteristics of the Electrostatic Lens of a New Type Field Emission Gun"; received October 1982, draft finalized April 1983.]

[Text] English Abstract: The construction and calculation results of a hyperboloidal field of unipotential electrostatic lens with low spherical aberration is presented, by which the performance of the electron optical system of the field emission gun can be easily improved.

In a field emission gun, the relationship between the optimum aperture angle α_{opt} and the maximum beam I_{max} and the spherical aberration coefficient of the lens C_{s2} are respectively

$$\alpha_{opt} = (d/C_{s2})^{1/3} \qquad (1)$$

$$I_{max} = 3^{1/4}\pi(dI/d\Omega)(V_2/V_1)^{1/4}(d^{3/2}/C_{s1}^{1/2}C_{s2}^{1/2}) \qquad (2)$$

in which C_{s1} and C_{s2} are the spherical aberration coefficient of the gun's lens and the probe lens, respectively and $dI/d\Omega$ is the angular emission rate of the tip of the cathode. Figure 1 is the design of the three light paths used in the field emission gun. In the figure, (a) is the first stage electrostatic lens used mainly in when the image position and the beam energy are fixed and the emission is relative stable; (b) is the second stage focusing system, sometimes the second stage lens is a magnetic lens, in this construction, the system magnification can be reduced for higher resolution;

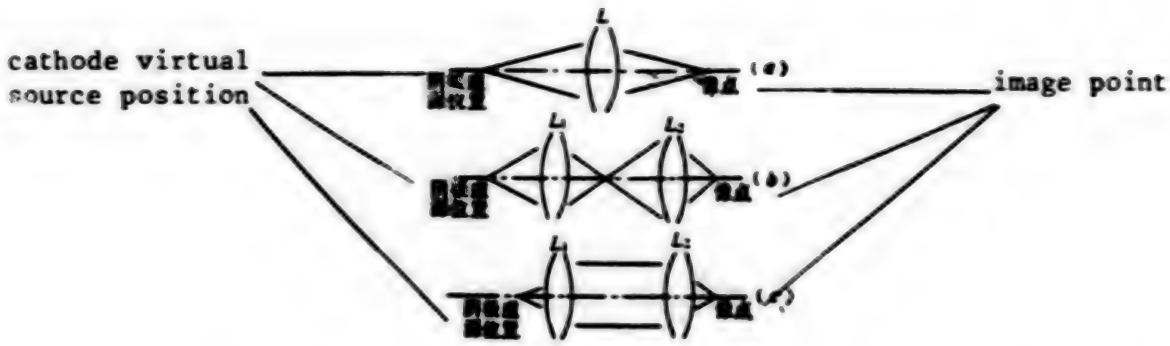
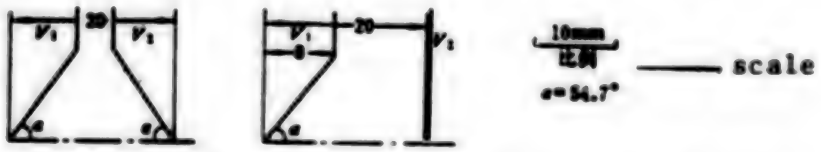


Figure 1. Design of three circuits of field emission gun

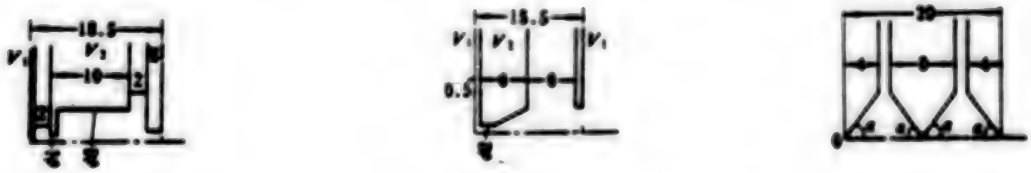
(c) is also a second stage focusing system, but the virtual source position and the lens focal position coincide, thus the influence of image aberration is minimal but the beam is very large (the geometric magnification of this system is the ratio of the focal length of the two lenses, and generally should be larger than the focal length of type (b)).

There are two types of electrostatic lenses now used in field emission guns: the dual potential lens and the unipotential lens. For the former, there are the simplified type in reference [1] and the hyperboloid lens of 109°28', and the latter includes the two asymmetrical structures in references [2] and [3]. Their typical construction is illustrated in Figure 2.



(a) hyperboloid field dual potential

(b) Munro simplified type



(c) Septier asymmetrical structure

(d) Riddle asymmetrical structure

(e) hyperboloid unipotential

Figure 2. Electrostatic lens structures of various field emission guns, point O corresponds to the focusing position in Table 1

Dual potential lenses generally require high voltage, but the end potential is limited by the working voltage, the first anode voltage also directly affects the size of the beam, thus it primarily should be used in cases where the voltage is fixed and the image formation position is fixed. Commonly, the unipotential lens is used as a pre-acceleration lens and it can change the beam and the end voltage (energy) within a larger range. The author used a new type of hyperboloid field unipotential lens, and through computer analysis shows that this lens can obtain a smaller spherical aberration coefficient at a longer focal length. This hyperboloid field unipotential lens can serve as the first stage lens of a field emission gun. See Figure 2(e) for its structure and the dimensions of the electrodes.

The author feels that when the focal length of the Riddle lens in Figure 2 is very short, there is a very small spherical aberration coefficient, but this is not suited to use at high voltages; although there is a small spherical aberration coefficient with the longer focal length of the Septier lens, if the light path illustrated in Figure 1(a) is used, changes can occur in the main plane position, leading to changes in the beam tension angle and this makes the circle of confusion spots ($C_3a^3/2$) created by spherical aberration even larger. The two sides of the hyperboloid field unipotential lens are summetrical, thus a better image formation result is obtained. Figure 3 gives the curve of the relationship between the focal length of the various lenses and the spherical aberration coefficient, Table 1 is the computation results of the structure and characteristics of the lens of typical dimensions illustrated in Figure 2(e), and provides a basis for references when deploying electron optical systems.

Table 1. Characteristics of hyperboloid field unipotential lens illustrated in Figure 2(e)
(VOLTAGE V_1 = 1)

Voltage (V_2)	Physical Aspect: projection point		physical point		spherical aberration coefficient	color-difference coefficient	spherical aberration/ focal length
	focal position	focal length	focal position	focal length			
0	727.2	717.5	9.97	0.48	0.137	0.166	0.28
0.1	5.44	6.93	5.38	5.66	27.83	20.72	4.92
0.2	0.28	10.94	0.28	10.94	104.6	48.78	9.57
0.3	-6.71	17.43	-6.71	17.43	333.0	59.96	19.11
0.4	-17.78	28.22	-17.78	28.22	1231.8	85.83	43.66
0.5	-37.14	47.40	-37.14	47.40	5362.3	130.1	113.1
0.6	-52.65	62.84	-52.65	62.84	12017	165.5	192.6
0.7	-108.5	118.7	-108.5	118.7	71510	290.4	653.2
0.8	-252.7	262.8	-252.7	262.8	809150	602.7	507.9
0.5	-119.4	133.6	-199.4	113.6	84330	214.9	631.4
2	-37.43	41.83	-37.43	47.83	3402.1	64.65	71.1
3	-10.24	21.52	-10.24	21.52	278.8	21.37	12.96
4	-3.12	15.62	-3.12	15.62	119.4	43.93	7.64
5	0.50	13.65	0.30	13.69	93.48	11.74	6.83
6	3.16	13.24	3.10	13.31	135.7	23.6	8.93
7	5.71	13.86	5.12	16.34	166.6	42.8	10.20
8	8.76	15.59	6.63	16.16	163.9	57.04	10.14
9	13.21	19.09	7.76	15.63	149.9	65.3	9.59
10	21.46	26.64	8.66	14.84	136.3	69.4	9.19

1. Because this is a symmetrical structure, only the physical characteristics are listed.
2. The focus point position takes the left side of the left electrode in Figure 2(e) as the coordinate's point of origin.

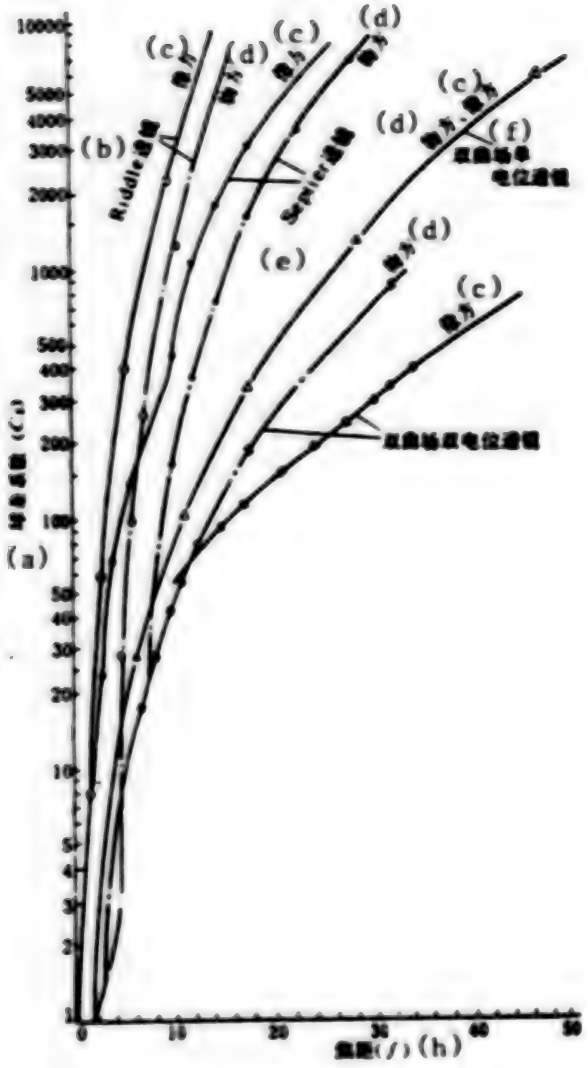


Figure 3. Curves of the relationship of focal length and spherical aberration of various lenses.

Key:

a. spherical aberration coefficient
b. Riddle lens
c. image
d. physical aspect
e. Septier lens
f. hyperploid field unipotential lens
g. hyperploid field dual potential lens
h. focal length

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APPLIED SCIENCES

TRENDS IN DEVELOPMENT OF ELECTRON OPTICS

Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 12, No 2, Mar 84 pp 90-96

[Article by Ximen Jiye [6007 7024 4764 2814], Beijing University, Department of Radio-electronics; received July 1983]

[Text] English Abstract: The main trends in the development of electron optics have been discussed. The following are noteworthy: rotationally symmetrical electron optics for the weak narrow electron beam, electron optical matrix algebra and optimization design, non-rotationally symmetrical multipole systems, the progress of scanning electron beam systems--a combined focusing-deflection system, electron optics for the wide electron beam, electron and ion optical systems with a curvilinear axis, wave electron optics. The future development and applications of electron optics have also been outlined.

Electron optics is a scientific field that studies the laws of electrons in focusing, image formation, and deflection in electromagnetic fields. Using classical dynamics, classical electrodynamics, and optics as the theoretical foundation and relying on the similarities between the movement of electrons and ions in electromagnetic fields and the propagation rays in optical media, adopting optics-like methods and concepts (such as variation principle, aberration function, refractivity, rays, lenses and aberration) people have established a complete theoretical system of electron optics to study and explain these laws [1,2].

The origins of electron optics theory can be traced back to the principle of the shortest optical path in the 17th century, Maupertuis-Eyler's principle of least action in the 18th century, and Hamilton's variation principle and Maxwell's electromagnetic theory in the 19th century. However, the real beginning of electron optics developed around the problem of rotationally symmetrical weak narrow beam electron optics. For example, H. Busch's treatise on magnetic focusing in 1926 and the theoretical articles of W. Glaser and O. Scherzer on rotationally symmetric electron optics in 1932-1937 laid the theoretical foundation for electron optics. In the past 50 years, with the development of science and technology and production practice, electron optics penetrated many areas of science and technology more and more each day. For example, the fields of ratio electronics, electron microscopy, mass-spectroscopy, surface physics, materials science, high energy physics, and

plasma physics all involve problems of production, control and use of electron particle beams and all should use the achievements of this field of science. In terms of research and development and improving electron optics products (including components, instruments and devices) present electron optics theory is playing an extremely important role and the development of new components, instruments and devices is also opening up new areas and promoting their development for electron optics.

In looking at the prospects in this area on the basis of the flourishing development of electron optics, this paper stresses the introduction of some trends in the development of electron optics which are worthy of attention. For the principles of the electron and ion optics touched on in this paper please see reference [2].

Rotationally Symmetric Weak Narrow Beam Electron Optics

Rotationally symmetric weak narrow beam electron optics, which is the foundation of electron optics, is very highly developed and has a complete form. It is widely used in electron beam components (such as display tubes and oscilloscopes), electron optics instruments (such as transmissive electron microscopes and electron probes) and in electron optical equipment (such as electron beam exposer and electron beam processor).

An electron optics image formation system is made up of a certain number of rotationally symmetric electron lenses which can focus the electron rays to form an image. At present, the point resolution of high performance transmission electron microscopes is 2-3 A, with crystal lattice line resolution of about 1 A, they can observe the image of heavy metal elements and large molecules, and can directly scan and photograph the matrix and structure of crystals[3]; the resolution of scanning electron microscopes is 30-50 A, they can directly observe the surface image of samples and, when equipped with spectrograph, can carry out constituent analysis [3]. These achievements are outstanding applications of electron optics theory.

Electromagnetic deflection systems are made up of a magnetic field and an electrical field perpendicular to the electron beam's direction of motion and change the direction of the electron beam to produce deflection [4]. For example, the electrostatic or magnetic deflection system adopted in an electron beam component causes the electron beam to scan in order to record or display the image created; the magnetic deflection system used in an electron optical instrument or device makes the electron beam scan and deflect. The modern trinitron uses a perfected zihui juci [5261 2585 5112 4318] deflection coil to optimize the distribution of the deflected magnetic field (deflection angle 100°). This remarkable achievement drew on research on magnetic deflection system electron optics aberration [5,6]. Recently, reference [7] had done further work on third level aberration of magnetic deflection and electrical deflection.

Beginning in the sixties, and especially since the early eighties, computer-aided design has also been broadly applied to research and design in electron optics, successfully resolving the following problems [2,8].

(1) Computing electron fields and magnetic fields, including rotationally symmetric fields, deflection fields and multipole fields.

(2) Computing paths of motion of charged particles in electron and magnetic fields; solving equations of motion or equations of path taking space charged conditions into consideration or not (using processing methods of the single electron model or statistical model).

(3) Computing Gauss optical parameters in electron optics systems, including physical and image position of the image forming lens, magnification, focal point and focal length, and sensitivity of the deflector.

(4) Computing aberration, including geometric image and chromatic aberration of image forming systems and multipole systems, image aberration of deflection systems, and image aberration caused by other perturbation.

(5) Computing other optical performance norms, such as carrier function, resolution, imaging contrast and diffraction contrast, and phase, amplitude, and intensity.

Computer aided design makes classical electron optics theory and the development of components, instruments, and devices much easier and has vigorously promoted the development of weak narrow beam electron optics.

Electron Optical Matrix Algebra and Optimization Design

Multiple lens systems made up of a series of lenses or a multi-level deflection system made up of a series of deflectors in electron optics components, instruments, and devices can be viewed as an electron optics system. For example, three and four level image formation systems of transmission microscopes, the two and three level probe systems in scanning electron microscopes, and the dual deflection systems in electron beam exploders.

When designing multi-lens systems, an important problem is the need to determine accurately the system's Gaussian optical transformation properties and the image aberration transmission properties, and the properties of each lens and how its image aberration affects the ultimate image. In recent years, an entire matrix algebra method [2] has been developed in electron optics, that is defined as a series of matrices including the first level and third level path parameters, and their transformation between the initial plane and the final plane can be described by a transformation matrix. This transformation matrix comprehensively embodies the first level (Gauss) optical properties and third level image aberration properties of the lens. We have proven [9] that when an initial level image aberration exists in a rotationally symmetrical electron optics system, the determinant number of the transformation matrix is 1; when going through successive electron optics systems, the transformation matrix multiplies, thus the determinant number of the overall transformation matrix is also 1. This conclusion is the application of Liouville's theorem, and it contributed to the development of the matrix algebra theory of electron optics systems when there is initial level image aberration. We also studied superposition of image aberration in multi-level electro-magnetic deflection systems; the form of the formula obtained is simple and convenient for carrying out computer-aided and optimization design [10].

In recent years, great advances have been made in using computers for optimization design of electron optics systems. The basic topics in optimization design methods are: finding the optimal lens field distribution or structural parameters under conditions of restrictions on the parameters of lenses (such as geometrical shape and position, electron parameters or optical parameters) so that the total image aberration is minimal or does not go beyond a stipulated range and a perfected image is obtained. Thus the variational method [11], dynamic planning method [12], simplex method and complex method [13] can be adopted. Optimized design can carry out contrasts of a large number of plans according to a definite evaluation standard and rapidly select from among them the optimum scheme which conforms to certain demands. This accelerates the design and testing process of electron optics systems.

Non-rotationally Symmetric Multipole Systems

Historically, research on rotationally symmetric electron optic systems has been highly regarded. Later on, people strove to find better, more convenient and more effective electro-magnetic fields for electron beam focusing and image formation, so the non-rotationally symmetrical electro-magnetic multipole system came into being.

Electro-magnetic multipole systems are systems made up of several electric (magnetic) poles having a definite electric (magnetic) potential symmetrically placed in the direction of the bearing angle. The non-rotationally symmetrical fields produced by these multipole systems are multipole fields. Based on the above described symmetrical nature, the electric (magnetic) potential of multipole fields should be a periodic function of the space bearing angle direction. Thus, the problem of finding the spatial three-dimensional multipole field distribution becomes a problem of finding a series of two dimensional harmonic electric (magnetic) potentials. This Fourier derived method can find multipole fields precisely [14].

From this it can be seen that there are different focusing and defocusing in the meridian plane of different bearing angles in multipole fields. For example, four-pole lenses are focused in one meridian plane but in another meridian plane perpendicular to this one are defocused. Clearly, multipole systems are developments of rotationally symmetrical systems, have more varied natures, and can be broadly applied [15]. For example, four-pole, six-pole and eight-pole lenses in electron beam devices and electron microscopes are used as image aberration correctors (correcting axial astigmatism, central chromatic aberration, and spherical aberration); in mass spectrometers they are used as focus deflection components; and in accelerators they are used as beam transmission components.

As concerns the problem of eliminating spherical aberration in multipole lenses, in 1936, Scherzer [16] proved that in electron optical lens systems which do not have space charged, static and rotationally symmetrical image formation, spherical aberration cannot be eliminated. In 1947 he also proposed using an eight-pole lens system as a spherical aberration corrector [17], but this has not yet been very well realized due to the complexity of the structure and the difficulty of adjustment. In recent years, references [18] and [19] have proposed using magnetic six-pole lenses as spherical aberration correctors. The

structure used by this method is simpler, adjustment is easy, and it has caught the attention of some people. Reference [20] discusses the optical properties of a complex system composed of a definite magnetic six-pole lenses distributed along the axis and graphic lens field distribution overlapping, and its second, third, fourth, and fifth level image aberration, but what is produced is only the image aberration (spherical aberration) in the Gaussian image plane and no image aberration outside the axis is produced. In reference [21] we further produce axial and extra-axial second, third and fourth level image aberration of a complex system formed by the overlap of any magnetic picture lens and the field distribution of a magnetic six-pole lens. These documents [16-18] all prove that the magnetic six-pole lens can correct the spherical aberration of picture lenses. If they are further realized in devices there can be very big breakthroughs.

New Developments in Scanning Beam Electron Optics: Focusing-Deflection Systems

Two different electron optics systems are used in ordinary electron optics devices. One type is the traditional and familiar fixed beam electron optics system (such as the image formation system of the transmission electron microscope). Its overall picture is produced at one time, thus frequently static methods are used to correct image aberration. The discussions in the above sections were referring to fixed beam electron optics systems. The other type is the relatively recently developed scanning electron optical system (such as the probe system of the scanning electron microscope and the picture production system of the electron beam exploder). Their electronic pictures are created by scanning points in succession in a series of instants, and thus dynamic methods can be used for correcting image aberration. This section will discuss the scanning beam electron optical systems. In this system, the electro-magnetic lens is used to focus the electron beam and the electo-magnetic deflector is used to make the electron beam deflect the scan.

The focal field and the deflection field of the scanning electron optical systems of the scanning electron microscope and the electron probe are separated in space and do not overlap. Thus, the theory discussed in the proceding sections can be used for processing. The electron beam scan range in these devices is small (about several square microns) and thus the deflection image aberration is also small.

The scanning electron optical systems in electron beam exploders have their differences. This is because the manufacturing process of large scale integrated circuits demands that the electron beam exploders have large scanning ranges (several square millimeters), high resolution (submicron line width) and low image aberration. A unique scanning electron optical system has already been studied and designed, i.e., it will overlap in space the electro-magnetic lens field and the electro-magnetic deflection field to form a compound focus-deflection system. In this system, the magnetic deflection diagram is placed in the magnetic lens field, thus it can make some magnetic deflection image aberration supplement appropriately the extra-axial image aberration of the magnetic lens. The overall image aberration of this compound focusing-deflection system can be sharply reduced.

Since the seventies there have been great advances in research on compound focusing-deflection system electron optics theory [22-25]. We have derived the relative first level chromatic aberration and relative third level geometric image aberration of ordinary compound electro-magnetic focusing-deflection system and found clear equations for image aberration coefficients to facilitate electron optical design and numerical calculation by computer; we also discussed the problem of image overlap in multipole electro-magnetic compound deflection systems. Recently, reference [26] computed the field distribution and electron optical image aberration of compound focusing-deflection systems, discussed the problems of their optimized design and formulated corresponding general purpose procedures.

Recently, people have increasingly paid attention to correcting the image aberration of scanning electron optical systems. As discussed above, scanning electron optical systems can use dynamic methods to correct image aberration. Reference [27] says that in principal, third level image aberration of scanning electron optical systems can be eliminated. References [24] and [28] discuss the feasibility of adopting animated lens corrected image aberration in compound focusing-deflection systems. We discussed [29] the feasibility of using different electro-magnetic multipole fields as compound focusing-deflection systems dynamic image aberration correctors (such as using picture correction lenses, deflection correction fields and fourth level and sixth level correction fields), derived the corresponding image aberration equations, and proved that this dynamic image correction system can, under certain conditions, eliminate most of the third level deflection image aberration of compound systems.

Broad Beam Electron Optics Systems

In ordinary narrow beam electron optical devices (such as electron microscopes) and components (such as display tubes and oscilloscope tubes), the electron beam satisfies paraxial conditions, i.e., the distances from the axis are very small, and also very small relative to the gradient of the axis. Satisfying these conditions, approximate narrow-beam ideal Gaussian optical imaging properties can be derived and the tertiary geometric image aberration and primary chromatic aberration described using the paraxial path parameters.

In another large class of electron beam devices (such as image converter tubes and image intensifiers) the cathode emits electrons at a very small initial velocity; the cathode is immersed in the electrical field (and magnetic field) and is itself the surface of the object it is imaging. Thus, the electron beam does not satisfy the conditions of very small axial gradient (actually, the gradient of the electron beam intersecting the surface of the cathode tends to infinity), but it satisfies the conditions of being near the axis, i.e., the distance from the axis is very small and the horizontal velocity is very small. This type of electron beam is called the broad electron beam. Satisfying the adaxial condition, the approximate broad-beam ideal Gaussian optical imaging expression can be derived and the tertiary geometric image aberration and primary chromatic aberration described using the adaxial path parameters [30].

The author's strict theory of electromagnetic compound focusing cathode lens tertiary image aberration first established in 1957 [30] laid the foundation

for broad-beam electron optics development. Recently there have been other developments [31] deriving image aberration of electromagnetic compound focusing lenses in any imaging plane.

For a long time in traditional electron optics documents, people have felt that narrow beam electron optical systems and broad-beam electron optical systems are two different kinds of systems, therefore they have used different methods to compute image aberrations. Recently, in reference [32], the author and other collaborators, proceeding from the variation principle, have studied image aberration theory of electromagnetic compound focusing cathode lenses, and obtained general equations for image aberration coefficients in any plane. They can be expressed using the image aberration coefficient linear composition derived by Glaser [1]. This demonstrates that image aberration of broad-beam and narrow-beam electron optical systems can be processed using uniform variation methods and thus establishes a connection between the two.

With developments in picture intensity technology, television technology, and electron photography technology, there have also been developments in broad-beam electron optics focusing theory [33], i.e., theoretical analysis of electromagnetic concentric focusing systems and electron optics research on inclined electromagnetic focusing systems.

Curvilinear Axis Electron and Ion Optical Systems

Traditional electron optics systems are straightline axis electron optics systems, and in them the primary paths of paraxial or adaxial electron beams are rotationally symmetrical straightline axes. However, there is a large class of widely used devices with charged particle (including electrons and ions) spectrographs which generally use curvilinear electron and ion optical systems--different types of electron field and magnetic field analyzers. Such electron field analyzers as cylindrical capacitors, spherical capacitors, and ring capacitors or uniform magnetic field and non-uniform magnetic field analyzers are used in charged particle spectrographs. The electron and magnetic fields of these analyzers are rotationally symmetrical fields. If the symmetrical surface of the mirror image perpendicular to the rotationally symmetrical axis is taken as the reference plane, the charged particle beams in this plane have cylindrical paths. Thus it can be seen that this is a curvilinear electron and ion optical system and is quite different from the straightline axis electron optics systems discussed above.

The most important characteristic of the curvilinear electron and ion optics systems is that they have special mass dispersion and energy dispersion properites. In fact, when charged particles of certain charge, certain mass, and certain energy (or momentum) is moving in an electron or magnetic field, they move along a cylindrical path with a definite radius in the mirror image plane. When charged particles have mass dispersion, energy dispersion, or momentum dispersion, the primary path will shift laterally (radially) and this is called chromatic aberration. Charged particle spectrographs can be manufactured using precisely this chromatic dispersion property: the analytical device which makes charged particles split according to mass is called a mass spectrograph; the analytical device that makes charged particles split according to energy and

momentum is called an energy spectrograph. Next, the curvilinear electron and ion optics system on the one hand causes deflection in the charged particle beam (corresponding to the optical prism) and, on the other hand, also makes the charged particle beam focus (corresponding to the optical lens). Actually, this is a combination of prism and lens, generally called an ion lens. The commonly used ion lenses are fan-field ion lenses, i.e., the field distribution of the electron or magnetic field analyzer is limited to a certain fan field angle, and the intensity outside this fan field domain is zero. Apart from having the deflection and focusing functions described above, this type of fan field ion lens can also be used for describing optical properties in terms of such concepts as focal point and focal length. In primary approximation it can be proven that fan-shaped ion lenses have ideal focusing properties; if secondary and tertiary influences are considered, secondary and tertiary image aberrations will appear.

In references [2, 34, 35] we discussed universal electron field-magnetic field analyzers, i.e., ring-shaped electron fields and heterogeneous magnetic field orthogonal configuration fan-shaped overlapping field analyzers; expounded the secondary and tertiary ion optics theory of such fan-shaped overlapping fields and obtained matrix notation forms for secondary and tertiary ion paths and derived secondary and tertiary ion optics image aberration coefficients; discussed the transformation matrices of primary to secondary overlapping field ion lenses and proved that Liouville's theorem still held up to tertiary approximations. Recently we also derived secondary and tertiary transformation matrices under the action of fan-shaped overlapping field gradient exit and entrance [36]. These universal theories are important for developing fan-shaped ion optics theory and matrix algebra methods.

With the development of ion optics theory [37], high performance and multifunction mass spectrometers are constantly appearing. For example, the isotope mass spectrograph with a precision of 1ppm; the organic mass spectrograph with a resolution of 150,000, the solid micromass spectrograph which measures 10^{-10}, the ion probe spectro-micrograph analyzer which can analyze solid microregional ($1\ m^2$) impurity distribution and depth (dozens of angstroms) impurity distribution of solids.

In recent years the performance of electron energy spectrographs has constantly improved and correspondingly, electron energy spectrography has also developed rapidly [38]. Thus, we should point out an important event, i.e., K. Siegbahn, a physicist and professor at Upsala University in Sweden won the Nobel Prize for physics in 1981 because of his outstanding contributions in many years to developing high resolution X-ray electron energy spectrographs and developments in X-ray electron energy spectrography. This fact suggests a bright future for this new science.

Wave Electron Optics

Although many properties of image formation systems can be explained using geometric optic concepts (such as electron rays, focal point, focal length and geometric image aberration) some phenomena related to electron waves (such as interference, diffraction, Fresnel fringe, resolution and transmission functions) must be explained with the help of wave electron optics.

The foundation for wave electron optics was laid in the fifties by Glaser et al. [1]. Wave electron optics placed the emphasis on studying the wave properties of electron beams propagated in macro-electromagnetic fields (such as electron microscope lens fields) and microelectromagnetic fields (such as internal potential electron fields in crystals) and other laws (such as electron beam interference, diffraction and image formation). In the last 20 or 30 years there have been great developments in wave electron optics and have been broadly applied in electron microscopy [39] and electron diffraction physics [40].

Viewed from the perspective of the concepts of physics, the imaging mechanism of the electron microscope can be explained in terms of Abbe's theory of image formation [41]. The first step, the sample corresponds to a diffraction grating; with coherent illumination, parallel incident waves produce diffraction waves due to the scattering action of the sample, and through the back focus surface of the lens they form a diffraction image. The second step, the diffraction images are viewed as secondary disturbance centers, and generate interference in accordance with Huygen's principle, thus the image formation is refocused on the image surface. Using the strict Fourier transformation method, the first step is to obtain a diffraction spectrum on the back focus surface after the physical surface waves have been through the Fourier transformation; the second step is the formation of the final image on the image plane from the diffraction spectrum, again through Fourier transformation; the diaphragm and the lens image aberration can be reduced by adjustment of the diffraction spectrum. Thus, proceeding from Schroedinger's equation of the electron wave function, Fourier transformation is used to find the wave function in rotationally symmetrical electromagnetic fields with paraxial approximation and tertiary image aberration, and the next step is to compute the transmission function. The above described theory is called wave (Fourier) electron optics.

In recent years, high resolution electron microscopy has developed very rapidly and matched with computer digital image processing technology, research on electron microscope image processing is all the rage. An event which should delight all of us workers in electron optics is that Dr. A. Klug, of the British Medical Research Council's Molecular Biology Laboratory won the Nobel Prize for Chemistry in 1982 for his outstanding contributions in developing crystal electron microscopy and his research on the crystal structure of nucleic acid-protein complex [42]. It was Klug who developed an entire image processing method based on the Fourier transformation relationship of electron microscope image formation. This improved the chendu, clarity and resolution of electron microscope images, and thus opened new paths for using electron microscope in the study of large molecules and other solid crystal structures.

Conclusion

This section looks forward to the future development and application of electron optics. In the eighties, the resolution and sensitivity of electron and ion optics analytical devices will constantly improve and may play a greater role in exploring the micro-world (for example, direct observation of atoms). In large scale and very large scale integrated circuits, adopting sub-micron diameter electron beam ultra-narrow-beam processing technology (by the end of this century we may achieve atomic level processing technology) will be helped

by the development of ultra-high speed, ultra-large capacity computers. New developments in electron beam devices will certainly give rise to innovations in television, telecommunications, and photoelectric technology so that radio electronics will have a new look. New achievements in electron and ion optics and the design and manufacture of newer high energy accelerators and synchronous emanators will provide more powerful techniques for studying basic particles and mass structures. It can be estimated that electron and ion optics will play a larger role in science and technology and from this will draw driving forces and bring about greater developments in theory.

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APPLIED SCIENCES

CALCULATING INTERCONTINENTAL VEHICLE RANGE, ACCURACY

Beijing SHUXUE DE SHIJIAN YU RENSHI [MATHEMATICS IN PRACTICE AND THEORY] in Chinese No 3, Jul 85 pp 1-4

[Article by Cai Yongfang*[5591 3057 5364] of Fuzhou Teachers' Vocational School]

[Text] This article provides a simplified means to calculate the range and accuracy of intercontinental rockets as well as working out the range and accuracy of China's first intercontinental rocket.

To facilitate computation below, the earth is treated as a perfect sphere of radius R = 6,371 km.

I. The Range and Launch Direction Angle of Intercontinental Rockets

1. Range of intercontinental rockets. Set the geographical coordinates of the launch point A and the descent point B to the (φ_1, θ_1) 及 (φ_2, θ_2), where $-90° \leqslant \varphi_i \leqslant 90°$, $-180° \leqslant \theta_i \leqslant 180°$, $i = 1, 2$. For points A, B construct meridian circles $\overset{\frown}{NAP}$ and $\overset{\frown}{NBQ}$ respectively and the great circle $\overset{\frown}{AB}$ where N is the north pole and great circle $\overset{\frown}{PQ}$ is the equator.

There is no harm in treating the earth as a unit sphere. In the spherical triangle $\triangle ANB$, $\overset{\frown}{NA} = \frac{\pi}{2} - \varphi_1, \overset{\frown}{NB} = \frac{\pi}{2} - \varphi_2, \overset{\frown}{AB} = \angle AOB = \phi$ (where O is the center of the earth), the angle $ANB = \angle POQ = \theta_2 - \theta_1$. From the cosine law for sides

$$\begin{aligned}\cos\phi &= \cos\left(\frac{\pi}{2} - \varphi_1\right)\cos\left(\frac{\pi}{2} - \varphi_2\right) \\ &\quad + \sin\left(\frac{\pi}{2} - \varphi_1\right) \\ &\quad \cdot \sin\left(\frac{\pi}{2} - \varphi_2\right)\cos(\theta_2 - \theta_1) \\ &= \sin\varphi_1\sin\varphi_2 + \cos\varphi_1\cos\varphi_2\cos(\theta_2 - \theta_1),\end{aligned}$$

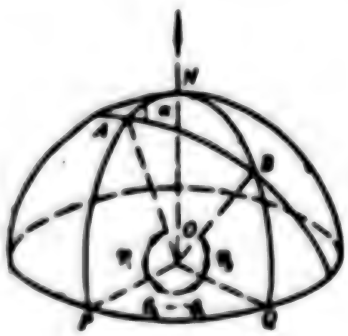

Figure 1.

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thus $$\phi = \cos^{-1}[\sin\varphi_1 \sin\varphi_2 + \cos\varphi_1 \cos\varphi_2 \cos(\theta_2 - \theta_1)], \qquad (1)$$

and the range of an intercontinental rocket is the shortest distance between the two points A, B

$$L = R \cdot \phi. \qquad (2)$$

According to inferences from [4], [5] it is known that China's first transport rocket was launched from Jiuquan in the northwest. From geographical calculation the coordinates of Jiuquan are approximately 39°42'N 98°28'E and the predetermined descent point is 7°S 171°33'E in the Pacific Ocean so with $\varphi_1 = 39°42'$, $\theta_1 = 98°28'$; $\varphi_2 = -7°$, $\theta_2 = 171°33'$ inserted in (1) we get

$$\phi = 81°42' = 1.4259 \text{ (radians)}$$

From (2) we get the rocket range

$$L = 6371 \times 1.4259 = 9084.4 \text{ (km)}$$

2. Launch direction angle. In the spherical triangle $\triangle ANB$, the angle NAB is the included angle between the northern direction of the meridian passing through the launch point and the projection of the flight path on the earth. Making $\angle NAB = \alpha$, from the law of sines

$$\frac{\sin\left(\frac{\pi}{2} - \varphi_2\right)}{\sin\alpha} = \frac{\sin\phi}{\sin(\theta_2 - \theta_1)}$$

we get the launch direction angle

$$\alpha = \sin^{-1}\left[\frac{\sin(\theta_2 - \theta_1)\cos\varphi_2}{\sin\phi}\right]. \qquad (3)$$

Substituting the values for $\theta_1, \theta_2, \varphi_2, \phi$ into (3) the launch direction angle of the rocket at Jiuquan is

$$\alpha = 73°38'30''.$$

II. Flight Path Deviation

Suppose the rocket descends within the circular region σ with the point B as center and radius r. Because r is usually greater than 10km, in these cases σ is actually a spherical segment.

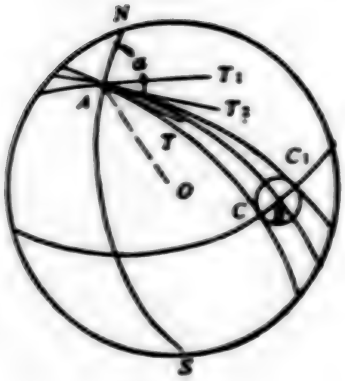

Figure 2

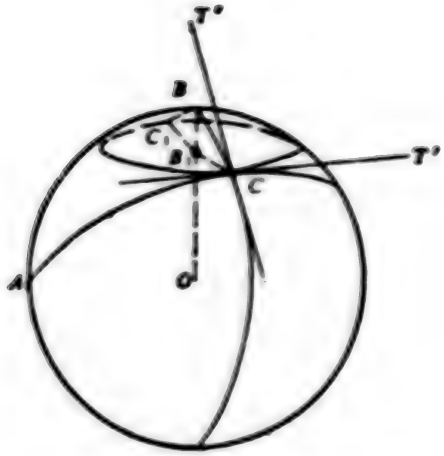

Figure 3

Make the two great circles through the launch point A tangent to σ (the base circle of the spherical segment) at the points C and C_1. The necessary but not sufficient condition to make the descent point within σ is that the flight path must lay within the solid angle C-DA-C_1 formed by the two half planes OAC and OAC_1. This angle is the maximum deviation angle that can be tolerated in the aiming direction at launch time. Below, it will be shown that this angle is twice the launch direction angle deviation $\Delta\alpha$ (i.e., spherical angle CAB).

To get $\Delta\alpha$, make great circles through B, C obtaining the spherical triangle ΔACB. Suppose the earth turned about the center O to make B occupy the place originally occupied by the north pole and to place A as in the outline of the earth in Figure 3. Now the circular region σ is the spherical segment BCC_1 and the arc $\widehat{CC_1}$ about the small circle B_1 is equivalent to a parallel [of latitude] and the great circle arc $\widehat{BC}$ is equivalent to a meridian [of longitude]. Make CT' and CT" be the tangents at C to $\widehat{CC_1}$ and $\widehat{BC}$ respectively. Because parallels and meridians are mutually perpendicular, CT'$\perp$CT", and since $\widehat{CC_1}$ and $\widehat{AC}$ intersect at the point C, CT' is also a tangent to $\widehat{AC}$ and as a result

$$\widehat{AC} \perp \widehat{BC} \text{ and the spherical angle ACB} = 90°.$$

In the spherical right triangle ΔACB, apply the law of sines

$$\sin A = \frac{\sin \widehat{BC}}{\sin \widehat{AB}} \qquad (\text{angle } A = \Delta\alpha),$$

thereupon

$$\Delta\alpha = \sin^{-1}\left(\frac{\sin \widehat{BC}}{\sin \widehat{AB}}\right), \qquad (4)$$

in which the great circle arcs $\widehat{AB}$, $\widehat{BC}$ are equal to the respective measure of the angles made from the center of the earth and can be found from the range and radius of the descent area respectively.

Similar to the above, make the great circle arc $\overset{\frown}{BC_1}$ (the great circle arcs $\overset{\frown}{BC_1}$ and $\overset{\frown}{BC}$ are not coplaner) and similarly $\overset{\frown}{AC_1}$ $\overset{\frown}{BC_1}$. Moreover from the formulae for spherical right triangles it is not difficult to show that

$$\angle CAB = \angle C_1AB, \text{ that is } \angle TAT_1 = \angle T_1AT_2,$$

in which AT, AT_1, AT_2 are the tangents through point A (Figure 2) to the great circle arcs $\overset{\frown}{AC}$, $\overset{\frown}{AC_1}$, and $\overset{\frown}{AB}$ respectively.

Moreover since

$$AT \perp OA, \ AT_1 \perp OA,$$

then:

The plane angle $\angle TAT_1$ of the solid angle C-OA-C is equal to 2 $\angle TAT_2$; that is the maximum deviation angle is equal to twice the launch deviation angle $\Delta\alpha$.

A great many factors influence the deviation in the rocket's descent point apart from errors in the launch direction angle, there is instrument error caused by the guidance system instrumentation, systematic error caused by simplifications in the guidance equations, error caused by propulsion residual when the engines shut down in the powered phase of the trajectory, and reentry errors which arise from changes in atmospheric elements during reentry of the projectile nose. Only after complex calculation and precise exterior trajectory measurement can the errors be evaluated. For more advanced discussion of these aspects see [1].

According to the "Public Notes" the radius of the descent area of our transport rocket was r = 70 nautical miles = 129.64km. But aside from considerations of safety caused by the rocket's probable descent error there is also consideration of the needs of exterior trajectory measurement work done in the descent area. For these reasons here we use 1/n (n = 1,2,...) of the radius of the descent area to estimate the accuracy.

In formula (4) $\overset{\frown}{AB} = 81°42'$, $\overset{\frown}{BC} = 1/n(r/R) = 1/n(129.64/6,371) = 1°10'/n$ thus the deviation in rocket launch direction angle came out to be

$$\Delta\alpha_1 = \sin^{-1}\left(1.01059 \sin\frac{1°10'}{n}\right) \approx \frac{1°10'}{n}. \qquad (5)$$

When n = 1,2,3,... the launch direction angle deviation of corresponding radii of descent r, r/2, r/3, ... are

$$\Delta\alpha_1 = 1°11', \ \Delta\alpha_2 = 0°35', \ \Delta\alpha_3 = 0°23', \cdots.$$

This shows that when rockets follow a flight path within dihedral angles with separate plane angles of 2°22', 1°10', 0°46' and have a range around 9,080km they must descent in a circular area with B(-7°, 171°33') as center and have radii of 70, 35, 23.3 nautical miles respectively.

According to [6] or AFP Canberra dispatch ("Reference Information" 1980,5,20), on the basis of actual observation, the Australian Ministry of Defense said that the Chinese rocket splashed down at 7°S latitude and 172° E longitude. If this is correct then from B(-7°, 171°33') and B_1(-7°, 172°) on the basis of equation (2) we can get the spherical distance between these two points which is the descent point deviation.

$$\overset{\frown}{BB_1} = 6{,}371 \times 0.00771 = 49.1(\text{km}).$$

Also from equation (4) the deviation in launch direction angle comes out to be

$$\Delta\alpha = \sin^{-1}\left(\frac{\sin \overset{\frown}{BB_1}}{\sin \overset{\frown}{AB}}\right) = 0°26'47".$$

As mentioned previously, the factors influencing deviation at the descent point are many, so for the time being we take $\Delta\alpha = 0°26'47"$ as the "equivalent aiming angle deviation" of the rocket's trajectory.

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APPLIED SCIENCES

'FUZZY INFERENCE' SYSTEM TO DIAGNOSE AIRCRAFT HYDRAULIC FAULTS

Beijing SHUXUE DE SHIJIAN YU RENSHI [MATHEMATICS IN PRACTICE AND THEORY] in Chinese No 3, Jul 85 pp 14-18

[Article by Feng Shoupai [7364 1108 3269], Weng Weigang [5040 0251 4854], and Dong Liang [5516 2856] of the PLA Air Force Engineering College]

[Text] I. Introduction

Aircraft hydraulic systems, the drive systems which control attitude, extension and retraction of landing gear, and wing flaps, are composed of tens to over a hundred parts. These systems are complex and often give rise to puzzling faults. At present, reliance on visual signs and dependence on experience to judge the location of the causes of faults contribute to a greater incidence of 'flying blind,' waste of time and material, and forfeiture of combat readiness. The application of computers in fault diagnosis can increase precision and speed so as to conveniently array the prerequisites which create the fault. This is one effective way to improve the quality of aircraft maintenance.

The causes of system faults and the appearance of symptoms have a random or "Fuzzy" nature. In the process of diagnosis the language people use is also largely "vague." For example, "the pressure is low and the landing gear retracts slowly," "large clearance causes fierce indicator oscillation," etc. The diagnostic process actually is a kind of vague inference process. That is, relying on experience to detect various "relations" between causes and symptoms and to engage in inference. In this regard, currently a large quantity of experimental statistical material has already been amassed. Based on these statistics combined with fault mechanism analysis, this article takes natural language and transforms it into machine language and crystallize human experience to simulate a "Fuzzy inference" system.

The characteristic nature of the system is first to select from events a set of symptoms (input) and causes (output) of model fault events and store them in a computer. Then during diagnosis an input works in this system to diagnosis the causes (output).

Using an H-89D microcomputer to do retrospective diagnosis of 48 instances of faults in a certain model aircraft hydraulic system, 39 cases were diagnosed correctly the first time. Seven were diagnosed correctly after two or three times and in only four cases was there a discrepancy between diagnosis and

reality. Since the input and output both were in current common language it is not necessary to add other test information. It can be conveniently excluded and this satisfies people. This is where the application of "Fuzzy mathematics" to complex aeronautic equipment maintenance via a computer to combine human and machine diagnosis methods performs an advantageous service.

II. Establishment of a "Fuzzy Inference" Diagnostic Model

Diagnosis from symptom to cause can be understood as the continuation of two mappings. One is a mapping from major symptoms to cause type and the other is a mapping from auxiliary symptom to cause location. This is the general skeleton of "Fuzzy inference." Setting up two classes of mapping f_I and f_{II},

$$f_I: S \to D, \tag{1}$$

$$f_{II}: A \to K, \tag{2}$$

in which $S = \{s_1, s_2, \cdots, s_g\}$ is the complete set of major symptoms and $s_m (m = 1, 2, \cdots, g)$ are the concrete symptoms of each, $D = \{d_1, d_2, \cdots, d_n\}$ is the complete set of classes of causes and $d_j (j = 1, 2, \cdots, n)$ are the concrete causes of each, A = $\{a_1, a_2, \cdots, a_r\}$ is the complete set of auxiliary symptoms are $a_u (u = 1, 2, \cdots, r)$ are the concrete auxiliary symptoms of each. K = $\{k_1, k_2, \cdots, k_l\}$ is the complete set of cause locations, and $k_v (v = 1, 2, \cdots, l)$ are the concrete cause locations of each.

If $W = \{S, A\} = \{w_1, w_2, \cdots, w_{g+r}\}$ is used to represent the complete set of symptoms, then this provides the input of a set of symptoms $W_0 \subseteq W$, and, under the function of the two classes of mapping above, output of the corresponding cause classes $d_j \in D$ and cause locations $k_j \in K$.

(1) The partition of symptom groups

Before determining the special characteristic of one or two class mappings, the symptoms obtained from experimental statistics must be partitioned into major and auxiliary symptoms. The principles of partition are determined according to the quantity of information provided by the symptom in diagnosing cause classes.

Make $P(d_j|w_i) = \frac{N_{d_j}}{N_{w_i}}$ be the probability that with the symptom w_i the cause d_j will produce a fault. In the formula, N_{w_i} is the frequency of times the symptom w_i occurred and N_{d_j} is the frequency with which the fault, d_j occurred when the symptom w_i appeared. Moreover, $P_{(w_i)} = \{P_{(w_1)}, P_{(w_2)}, \cdots, P_{(w_{g+r})}\}$ is the probability distribution of symptom w, $P_{(w_i)} = \frac{N_{w_i}}{N_w}$, , in which N_w is the general frequency of appearance of all symptoms. N_{d_j}, N_{w_i}, N_w, above all

can be gotten from experimental statistics. This way the entropy equation which corresponds to $P(D \mid w_i)$ is

$$H(D|w_i) = -\sum_{j=1}^{s} P(d_j|w_i)\log_2 P(d_j|w_i), \qquad (3)$$

and the corresponding average entropy is

$$H(D|w) = \sum_{i=1}^{m+r} P(w_i)H(D|w_i). \qquad (4)$$

Selecting a level β, make symptom w_i where $\frac{H(D|w_i)}{H(D|w)} \leqslant \beta$ is the required major symptom; that is distinguish cause class d_j as the required symptom with more information and the others with less information are auxiliary symptoms. With regard to related symptoms $w_i, w_g, H(D|w_i) = H(D|w_g)$ $(i \neq g)$, then w_i, w_g both are auxiliary symptoms.

For a certain model, mechanical analysis of faults can be divided into four types: major pressure supply (d_1), auxiliary pressure supply (d_2), the extension and retraction sections (d_3), and the jet hydraulic control section (d_4).

According to over 10 years of statistics (not complete) for this model we get up to 65 symptom groups. Using β = 3.2 the above method screens out 12 of them as major symptoms; the rest all being auxiliary symptoms. For example, "vibrations of pressure gauge," "servo system pressure insufficient," "retraction of landing gear slow," and "afterburner jet engages slowly" are major symptoms. Represented sequentially we have the set of major symptoms $S=(s_1, s_2, \ldots, s_{12})$.

2. Determination of the characteristics of the first mapping

Selecting one set of typical fault incidents from experience, each incident can be described using a Fuzzy conditional sentence. For example, a certain aircraft is taxing slowly and the major system pressure is below normal values and also has strong oscillations. Later it was determined that the pump had a faulty piston. In the example of this incident, "system pressure below normal" and "strong oscillations" are major symptoms which in symbols would be, respectively, s_7, $s_6 \in S$; moreover, "non-working piston" belongs to the major pressure supply (d_1) class of causes, so the sentence is expressed as

$$\text{IF } s_7^1, s_6^1 \text{ THEN } d_1.$$

Similarly, we can obtain the corresponding set of conditional statements

$$\text{IF } s_{m_i}^j \subseteq S \text{ THEN } d_j \ (j = 1, 2, 3, 4),$$

where the superscript "j" in $S^i_{m_j}$ corresponds to the set of causes d_j and the subscript "i" indicates the ith conditional statement and "m" is its identification number.

Considering that the function of the appearance of each concrete symptom in the determination of the class of causes is not the same, that is the level of subordination of s_m with respect to d_j is not the same, the function of its subordination is

$$\mu_{s_{m_j}} \triangleq \begin{cases} \mu_{s_{m_j}}, & s_m = s^j_{m_j}, \\ 0. \end{cases}$$

Obviously for a certain symptom $s_m \in S$, the greater is use in diagnosing cause type d_j, the greater is its corresponding degree of subordination. In the determination of the size of the degree of subordination many kinds of factors must be considered. First to be considered are experimental statistics, second, in order to supplement the limitations of statistics, we must consider factors of mechanical analysis, the obvious degree of the symptom as it appears, and the degree of difficulty to obtain said symptom in the current situation. For these four factors we assign the corresponding weights l_1, l_2, l_3, l_4, to obtain one Fuzzy set of weight allocations

$$L = (l_1, l_2, l_3, l_4).$$

When we assign a grade for each system according to the four functions considered above we get a graded Fuzzy set

$$K_{s_{m_j}} = (K^{l_1}_{s_{m_j}}, K^{l_2}_{s_{m_j}}, K^{l_3}_{s_{m_j}}, K^{l_4}_{s_{m_j}}), \quad m = 1, 2, \cdots, 12, \quad j = 1, 2, \cdots 4,$$

and

$$\mu_{s_{m_j}} \triangleq \max\{K_{s_{m_j}} \hat{*} L\}, \tag{5}$$

where $\hat{*}$ is defined such that $a \hat{*} b = a + b - ab$.

The weight allocations are solicited from the experienced personnel. For a certain model aircraft the weight allocations assigned were

$$L = (0.4, 0.3, 0.2, 0.1).$$

For grades of concrete symptoms the first factor grade can be calculated directly from statistical material, that is $K^{l_1}_{s_{m_j}} = P(s_{m_j} | d_j) = \frac{N_{s_{m_j}}}{N_{d_j}}$, where N_{dj} and $N_{s_{m_j}}$ are respectively the general frequency that cause type d_j produces a fault and the frequency of occurrence of symptoms S_{m_j} under these conditions. The second, third, and fourth factor grades can first be assigned respective degrees of subordination then later broken up corresponding to concrete symptoms. The degree of subordination for each factor on a certain model aircraft is give in Table 1.

Table 1. Degree of Subordination Corresponding to Symptom Language

	Mechanical analysis K^1	Degree of manifestation K^2	Ease of acquisition K^3
$\mu_{ij}(s_m) = 1$	must occur	very severe	very easy to observe
$1 > \mu_{ij}(s_m) \geq 0.9$	extremely likely to occur	fairly severe	easy to observe
$0.9 > \mu_{ij}(s_m) \geq 0.7$	very likely to occur	severe	observable
$0.7 > \mu_{ij}(s_m) \geq 0.5$	could possibly occur	not very severe	fairly difficult to observe
$0.5 > \mu_{ij}(s_m) \geq 0.3$	some possibility of occurring	slight	difficult to observe
$0.3 > \mu_{ij}(s_m)$	some possibility of not occurring	very slight	very difficult to observe
$\mu_{ij}(s_m) = 0$	impossible to occur	no change	unobservable

For example, when a certain model aircraft takes off the pressure increases slowly S_{5_1} and the grade with respect to major pressure supply factor type fault d_1 is $\underset{\sim}{K}S_{5_1} = (0.8, 0.9, 0.3, 0.2)$. Thus from (5) the degree of subordination of this symptom with respect to cause type d_1 can be calculated to be

$$\mu_{S_1} = \max\{(0.4, 0.3, 0.2, 0.1) \oplus (0.8, 0.9, 0.3, 0.2)\} = 0.93.$$

Using the method above to calculate the degree of subordination $\mu_{s_{ij}}$, for each symptoms we can get a 12 row by 4 column cause type diagnostic matrix $R_d = (\mu_{s_{ij}})$ and store it in a computer. This is the characteristic of the first mapping. When input is provided under the operation of this mapping we can obtain a specific output.

Set $P_j = (\mu_{1j}, \mu_{2j}, \cdots, \mu_{12j})^T$, $j = 1, 2, 3, 4$ the central determinant vector of the matrix. During diagnosis if we input the set of symptoms $S=(s_1, s_2, \ldots, s_{12})$ where

$$s_m = \begin{cases} 1, & s_m \text{ symptom appears} \\ 0, & s_m \text{ symptom does not appear} \end{cases} \qquad m = 1, 2, \cdots, 12,$$

then

$$\mu_{dj}(S) = S \circ P_j = \bigvee_{s_m \in S} (s_m \wedge \mu_{s_{mj}}). \tag{6}$$

Selecting $X_{4j} = \max\{\mu_{4j}(S);\ j = 1, 2, 3, 4\}$ the corresponding d_j is the diagnosed cause type.

3. Determining the characteristics of the second mapping

A certain aircraft model has 53 auxiliary symptoms and 64 cause locations. Exactly like the above the effectiveness or subordination function μ_{uv} is calculated for each symptom a_u with respect to a certain cause location k_v providing a 53 row by 64 column cause location diagnostic matrix $R_k=(\mu_{uv})$, to be stored in the computer. This constitutes the characteristics of the second mapping. For a fixed input, under the effect of this mapping we obtain an output of a certain cause location.

Considering that there are more symptoms (53) and the range of discourse of symptoms is $A = \{a_1, a_2, \cdots, a_{53}\}$, during diagnosis it is not possible in the current situation to provide simultaneously the conditions of 53 symptoms. It is only possible to provide a small portion of them; that is to provide a symptom set $A_0 = \{a_1, a_2, \cdots, a_s\}$, A_0 as a subset of A (the subscripts do not indicate the same elements as in A). Consequently it is not appropriate to utilize formula (6) above to calculate output. Instead we use the principle of greatest subordination to seek output. Make

$$\mu_{g_v}(A_0) \triangleq \frac{\mu_{1v} \cdot \mu_{2v} \cdots \mu_{sv}}{\sum_{v=1}^{53} \mu_{1v} \cdot \mu_{2v} \cdots \mu_{sv}}, \qquad (7)$$

using $\mu_{g_v}(A_0)$ to be the subordination function of the symptom A_0 with respect to a certain cause location K_v. Select

$$\mu_{g_j}(A_0) = \max\{\mu_{g_v}(A_0);\ v = 1, 2, \cdots, 53\} \qquad (8)$$

to be the output of the cause location K_j diagnosed by the input of A_0.

III. Automatic Interrogation Diagnosis Model

During diagnosis the diagnostic symptoms provided by personnel at the site can contain mistakes and omissions that make it difficult for computer diagnosis. Because of this it is necessary to equip the computer with the capability of preventative automatic questioning with respect to the most important symptoms for diagnosis so as to facilitate implementation of human-machine dialogue to promote correct diagnosis.

During diagnostic interrogation the machine acts as follows: Given an input of a symptom set $A_0 = \{a_1, a_2, \cdots, a_s\}$ if the calculated result produces

$$\mu_{g_j}(A_0) = \max\{\mu_{g_v}(A_0);\ j = 1, 2, \cdots, 53\}, \qquad \text{make}$$

$$\varepsilon \triangleq \frac{\mu_{g_j}(A_0) - \mu_{g_i}(A_0)}{\mu_{g_j}(A_0)} \qquad (i \neq j), \qquad (9)$$

and if $\varepsilon < \theta$ integration is necessary, where θ is the threshold value, $0 < \theta < 1$.

Determination of θ is as follows:

Select from experimental statistics a set of incidents (as many as possible, not necessarily typical incidents, due to the situation of possible mistakes and omissions in the statistics provided). For each incident the symtom set A_0 and the cause location k_a are all known. Input A_0 for computer calculation to get

$$\mu_{E_i}(A_0) = \max\{\mu_{E_j}(A_0);\ j = 1, 2, \cdots, 53\},$$

and if $k_j = k_a$ then consider the diagnosis correct. Conversely, if

$$k_i = k_a\ (i \neq j),\ \mu_{E_i}(A_0) > \mu_{E_j}(A_0),$$ then consider the diagnosis incorrect.

From formula (9) compute the corresponding ε value $(0 < \varepsilon < 1)$, select step size λ, then according to each small interval $(\varepsilon_i, \varepsilon_{i+1})$ statistically determine the diagnosis number N_i, set up the calculated general frequency as N_I, and make $P(\varepsilon_i < \varepsilon \leqslant \varepsilon_{i+1}) = \frac{N_i}{N_I}$ be the probability of correct diagnosis with respect to the compounding interval $(\varepsilon_i, \varepsilon_{i+1})$. Calculate the distribution function from the probability of correct diagnosis for every interval

$$F(\varepsilon) = P\{\varepsilon \leqslant \varepsilon_i\} = \sum_{\varepsilon_i \in \Omega_i} P\{\varepsilon = q_i\},$$

Selecting the correct diagnosis probability α, then the corresponding value ε_i of $F(\varepsilon) = \sum_{\varepsilon_i \in \Omega_i} P\{\varepsilon = \varepsilon_i\} = \alpha$ as determined to be the threshold value θ.

For example, for a certain aircraft model we select from experience 46 fault incidents, separately calculate their probability of correct diagnosis, and distribution function as shown in Table 2 (where $\lambda = 0.05$). Taking the correct diagnosis probability $\alpha = 0.14$, then $F(0.85) = 0.14$, therefore $\theta = \varepsilon_i = 0.85$ and when $\varepsilon \leqslant 0.85$ interrogation is necessary.

Table 2

ε_i	0—0.55	0.6—0.7	0.75	0.8	0.85	0.9	1
$P(\varepsilon)$	0.02	0.025	0.02	0.03	0.045	0.3	0.45
$F(\varepsilon)$	0.02	0.045	0.065	0.095	0.14	0.54	1

The kinds of symptoms which are queried depends on the most probable cause K_j obtained after input of the known symptom set A_0. That is the symptoms most useful to diagnosis cause K_j are queried.

Make the serial number set calculated under symptoms A_0 be I. Then we get

$$\frac{\mu_{E_j}(A_0) - \mu_{E_i}(A_0)}{\mu_{E_j}(A_0)} \leqslant \theta\ \ (i \neq j),$$

then in the two columns K_i and K_j calculate subordination function difference value $\mu_{r_i} - \mu_{r_i}$ which corresponds to symptoms in A_0 which did not appear in each row. Also pick $X_b = \max\{\mu_{r_j} - \mu_{r_i}; r \in I\}$, then re-diagnose querying the corresponding symptom a_b.

This article was completed under the direction of Comrade Tang Lukang [0781 6922 1660] and also received assistance from comrades Zhang Hongmin [1728 3163 2404] and Li Anjing [2621 1344 0079] to whom we express our gratitude.

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12966/8309
CSO: 4008/1084

APPLIED SCIENCES

INVESTIGATION OF COLLIDING-MODE Nd:YAG LASER

Shanghai GUANGXUE XUEBAO [ACTA OPTICA SINICA] in Chinese Vol 5, No 9, Sep 85 pp 794-798

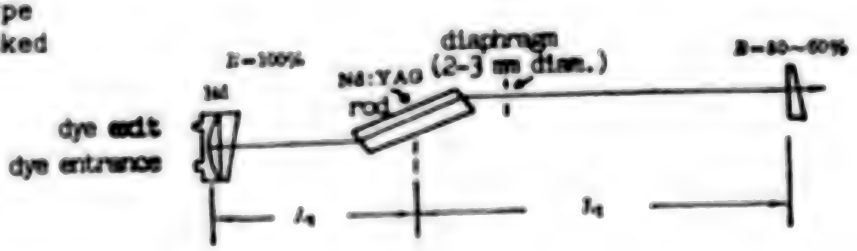
[Article by Lin Xing [2651 2502], Zhang Wenzhen [1728 2429 3741], Zhuang Huiming [8369 6540 7686] and Wu Fengtie [0702 6646 6993], Department of Physics, Huaqiao University, and Sun Zhan'ao [1327 0594 7663], Shanghai Institute of Optics and Precision Mechanics, CAS; manuscript received 5 February 1985, revised 23 March 1985]

[Text] ABSTRACT. The cavity configuration of a colliding-pulse mode-locked Nd:YAG laser is described. A stable mode-locked pulse train was observed with a 500-MHz oscilloscope; the average pulse width was about 10 ps. The relationship of the dye concentration to the mode locking threshold was studied in detail and mode-locked multiple pulses were shown to appear as the pumping energy was increased.

The colliding pulse mode [CPM] is a recently discovered mode-locking technique. In 1981, Fork et al. [1] first reported CPM operation in a ring dye laser, and in the last 2 years CMP operation has been achieved in Nd:YAG and Ar^+ lasers [3].

To achieve colliding-pulse mode locking in an Nd:YAG laser, we converted an SMG-1 mode-locked laser (produced by the Shanghai Institute of Optics and Precision Mechanics; see Fig. 1) into an antiresonant ring system as shown in Fig. 2.

Fig. 1. Contact-type reflective mode-locked Nd:YAG cavity



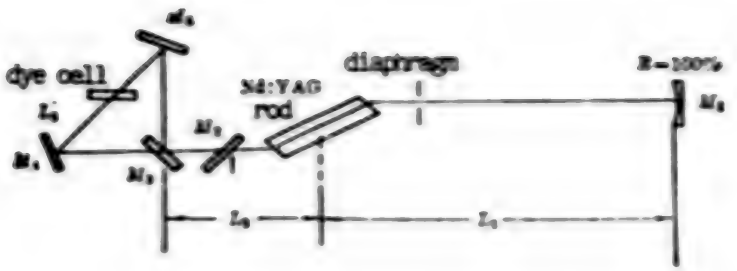


Fig. 2. Antiresonant ring CPM cavity

In Fig. 2, M_1 is a fully reflective mirror with Rd (radius of curvature) =3 m; M_2 and M_3 are semireflective (at 1.06 μm) dielectric-coated plates, M_4 and M_5 are dielectric-coated plates completely reflective at 1.06 μm, L_3 is the length of the antiresonant circuit, L_0, the total cavity length, is 1705 mm, the dye cell is placed outside the central interface of the ring cavity, and the dye used is pentamethine dissolved in 1,2-dichloroethane. M_2 not only serves as an output coupler, but also passes the mode-locked signal through an amplifying medium, providing one additional amplification of the output signal.

After adjustment of the optical circuit, a model 8801-21 photodiode was used as a detector at the output of lens M_2 and a 500-MHz oscilloscope was used to observe the waveform of the stable mode-locked pulse train, shown in Fig. 3. The conditions under which the photograph was taken were: 1000 V, 100 μf, dye transmissivity at 1.01 μm T_0 = 52.8 percent, cell thickness 1 mm, oscilloscope characteristics 200 mV/division, 20 ns/division, 10 repetitions per exposure. Under the same conditions, an SMJ-2 two-photon fluorescence pulse width meter was used to determine the pulse width, giving a result Δz = 1.67 mm (T_0 = 52.8 percent), from the equation $\Delta t_{TPF} = (\sqrt{2}\, n\Delta z/c)$ we found Δt_{TPF} = 10.4 ps. Measurements made under a variety of conditions indicated that when T_0 = 48-53 percent, the average mode-locked pulse width was 9-12 ps, about a third as wide as the 30-ps pulses obtained in the reflection method.

Below we investigate the relationship of the mode-locking threshold to the transmissivity, thickness and concentration of the dye solution.

1. Choice of Saturable Absorber Thickness

The relaxation time T_r of the dye, its concentration, and the dye cell thickness l are important parameters in obtaining shorter, more stable passive mode-locked pulses; they must meet the condition [4]

$$(2nd/c) < T_r. \qquad (1)$$

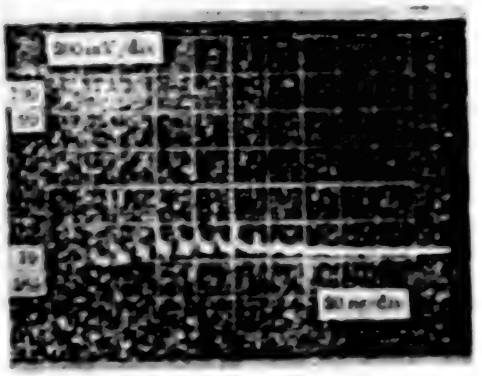


Fig. 3. Pulse train of colliding-pulse mode-locked Nd:YAG laser

For the solution of pentamethine dye dissolved in 1,2-dichloroethane that we used, T_r was 10-30 ps; for T_r = 20 ps and n = 1.45, d must not exceed 2 mm (where d is half the penetration length of the pulse in the dye solution, and for a transmission-type CPM structure d = $\ell/2$). Thus the effective length of the dye cell in the cavity must not exceed 4 mm. We used a dye cell 1 mm thick, which when placed at the Brewster angle had an effective thickness of 1.5 mm. If the thickness of the dye is equal to or less than the pulse length, there will be a clear-cut instantaneous grating effect. In practice, the dye cell requirements limited the small-signal transmissivity range, because stable operation occurs only when the loss per unit path length is less than 1.

In our experiments we generally used a dye cell thickness of 1 mm; the transmissivity of the two dye cell lenses to weak 1.06-μm light was 90 percent.

2. Preparation of Required Saturable Absorber Concentrations

With constant dye cell thickness, we discovered that the transmissivity of a freshly prepared dye solution was unstable. When measured the day after preparation, the small-signal transmissivity always showed an increase. Once this value had stabilized it would be maintained for several days. After stabilization, the required transmissivity could be achieved in accordance with the equation

$$T_0 = \exp(-\alpha_0 l/M), \qquad (2)$$

where α_0 is the linear absorption coefficient of the original dye solution (in our case, 5 mg of pentamethine dissolved in 10 ml of 1,2-dichloroethane), ℓ is the thickness of the dye cell, and M is the dilution factor. We used a model 751 spectrophotometer to determine the standard value (λ = 1.01 μm). Thus, by preparing a solution and determining T_0 (defined as the transmissivity of the dye, with the transmissivity of the dye cell subtracted from the measured value) and calculating α_0, equation (2) can be used to determine the dilution factor M needed to give the desired value of T_0. The calculation results showed good agreement with the standard values. For α_0 = 120 cm^{-1}

and M = 16, we obtain $T_0 \approx 52$ percent (for m = 1 mm), in agreement with the standard values).

3. Relationship of Mode-Locking Threshold to Dye Transmissivity

a. For a Given Dye Solution Thickness

To investigate the relationship of dye transmissivity to mode-locked lasing and stability [as published], we prepared several dye solutions with different transmissivities (i.e., concentrations) in accordance with equation (2). In our experiments we found that each concentration had a clear mode-locking threshold and that when the pumping energy was increased by a certain amount, multiple-pulse mode locking occurred; the results are shown in Table 1 and Fig. 4.

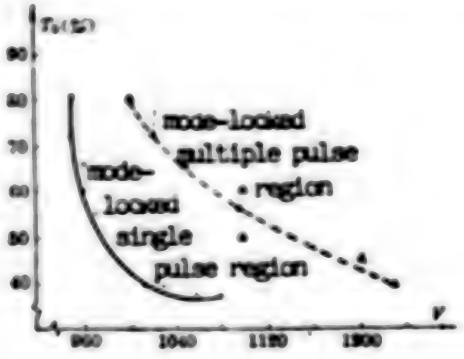


Fig. 4. Dye concentration versus mode-locking threshold

Table 1. Mode locking at various dye concentrations (Circles indicate single-pulse mode locking, triangles indicate multiple-pulse mode locking)

Voltage V / Transmissivity T_0	950	900	970	980	1000	1010	1020	1050	1080	1100	1120	1150	1180	1200	1220	1280
36.9%									○	○						
40.1%						○	○	○	○	○	○	○	○	○	○	△
46.1%					○		○	○	○	○	○	○	○	△	△	
50%		○		○	○			○	○	△		△				
56%			○		○			○	○	△		△				
59.9%		○		○	○		○	○	○	△		△	△	△	△	
66.1%		○		○	○		○	△	△	△	△	△	△	△	△	
72%	○	○		○	○		△	△								
80.5%	○	○		○	△		△									

In our experiments, the mode-locked pulse train was most stable when T_0 was about 50 percent; the peak value was then high and the single-pulse mode-locking region was at its broadest. When the concentration was increased, the mode-locking threshold rose and the output energy increased, but damage to the components was likely.

It can be seen from Fig. 4 that when the value of T_0 for the dye was 50 percent or more, the pumping threshold for mode locking was almost constant, but multiple pulses appeared earlier and the single-pulse mode locking region contracted as the dye concentration was decreased. Our experiments showed that when the pumping energy was increased to a certain value, single-pulse mode locking was replaced by multiple-pulse mode locking.

b. For Approximately Constant Transmissivity

For different dye cell thicknesses, we prepared dye solutions of different concentrations in order to achieve approximately equal cell transmissivities, then determined the mode-locking thresholds. The results are shown in Table 2.

It can be seen from Table 2 that for different dye cell thicknesses but approximtely equal transmissivities (i.e. with the thickness decreasing as the concentration increased), the mode-locking thresholds were approximately constant, indicating that for constant transmissivity, within a certain range the dye cell thickness has little effect on the mode-locking threshold.

Table 2. Relationship of cell thickness to mode-locking threshold for approximately constant transmissivity

Dye cell thickness l (mm)	1	1.5	2	2.5
Dye transmissivity T_0	50%	48.1%	51.4%	48.8%
Mode-locking threshold (V)	980	990	960	970

These experiments indicate that the mode-locking threshold is determined by the transmissivity of the dye solution and that different mode-locking thresholds can be achieved by varying the concentration and thickness of the dye solution; thus it is possible to vary the power of mode-locked pulses over a certain range.

4. Stability of Colliding-Pulse Mode Locking

In analyzing passive mode-locking cavity configurations and cavity parameters, we worked primarily with the TEM_{00} mode, and the mode-locked pulse trains were stable. The stability parameter S is defined as

$$K(\sigma_a/\sigma_p), \qquad (3)$$

where K is the ratio of the beam area at the amplifying medium to the beam area at the absorber; this is generally a constant larger than 1. When σ_a is the absorption cross section of the saturable absorber and σ_g is the amplification cross section of the amplifying medium, $(\sigma_a/\sigma_g) \gg 1$, so that the stability increases with increasing K.

a. Contact-Type Reflective Cavity

In the SMG-1 contact-type reflective cavity shown in Fig. 1, the dye cell is in close contact with the concave-back completely reflecting mirror (Rd = 3 m). This configuration uses the smallest components and there is no subcavity; the stability is somewhat better than for the non-contact type of cavity. Its deficiencies are: it is difficult to machine the composite dye cell; the concave reflector is difficult to replace if it is damaged, and the optimum radius of curvature Rd for the mirror is related to the refractive index of the dye [5]; and when the mirror is close to the dye it is likely to be affected by heating of the dye, with the result that the beam area in the absorbing medium will increase. For this configuration, $K < 1$.

b. Antiresonant Cavity

The antiresonant cavity shown in Fig. 2 is rather complex, but it has the advantage that the dye cell is easy to make. Provided that the dye cell is placed at the Brewster angle, subcavities are prevented, and under our experimental conditions the requirement regarding centering of the dye cell was not very strict: a deviation not exceeding ±2 mm has little effect on the output. For this cavity, $K > 1$, resulting in good stability. If M_4 and M_5 are changed to small-curvature completely reflective mirrors, the spot size in the saturable absorber can be further decreased, thus increasing K, and the dye cell can be distant from the concave fully reflective mirror, whose radius of curvature will not be affected by heating of the dye.

The equivalent optical path length of this cavity is $L_0 = L_1 + L_2 + (L_3/2)$, and the optimum radius of curvature for the concave mirror is subject to the condition [5]

$$4\left\{\left[2\frac{L_0}{L_1}+1\right]-\left[2-\left(2\frac{L_0}{L}-1\right)^2\right]^2\right\}^{-1} L_0 < R < 2L_0. \qquad (4)$$

In equation (4), provided that $[2(L_0/L) - 1]^2 \leq 2$, there is a real solution; the position of the rod must be such that $(L_1/L_0) = 5/6$. This can be achieved by shortening the ring length, so that the rod is as close as possible to the semireflective beam splitter.

In Fig. 2, if M_2 is absent, a new cavity configuration results, in which there is an output at M_3, but this configuration gives a rather small output energy,

and the optical components are likely to be damaged. When M_2 is added, because an additional amplification stage is introduced, the output energy is increased and the directionality and stability are improved.

Using a 500-MHz oscilloscope, we observed stable mode-locked pulse trains from the antiresonant cavity; the average pulse width determined with a two-photon fluorescence pulse width meter was about 10 ps. We analyzed the factors affecting passive mode-locking stability. The experiments showed that CPM operation had a distinct threshold and that the range of stable operation was rather wide. We investigated in detail the relationship of the CPM threshold to dye solution thickness, concentration and transmissivity. Multiple-exposure photographs indicated that the mode-locked pulse train stability was rather high and that the repetition rate was rather good. The dye cell in the CPM system was easy to fabricate, and replacing the cells and measuring the dye concentration were easy and economical, allowing repetitive operation. In addition, partial mode locking was also observed on the oscilloscope when a BDN dye film (0.1 mm) was used as a saturable absorber, indicating that the CPM system is favorable for passive mode-locked operation.

We believe that the relationships between various parameters of the Nd:YAG CPM system should be investigated further and that the optimum mode-locking conditions should be found in order to obtain even narrower pulses.

Other participants in the work included Comrades Zheng Yunshan [6774 0061 1472], Dai Jinlong [2071 6855 7893] and Zhuang Jinchuan [8369 6855 1557].

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8480
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ENVIRONMENTAL QUALITY

MAJOR EFFORT PRODUCES BETTER MARINE ENVIRONMENT PROTECTION

OW010254 Beijing XINHUA in English 0236 GMT 1 Mar 86

[Text] Beijing 1 March (XINHUA)--Since China promulgated the Marine Environmental Protection Law on 1 March 1983, there has been a marked improvement in the waters around China's coasts, according to the State Bureau of Oceanography here today.

The bureau is now holding a meeting on marine environment in Beijing to further enforce the law for marine pollution control.

Over the past few years China has established a national marine pollution monitoring network with 236 observation posts along the coast, collecting a huge amount of data on sea water, sediment and marine biology.

Last year, the bureau sent ships on over 200 patrol missions and planes on 70 missions to monitor the pollution in the country's territorial waters. It also handled the illegal dumping of pollutants in the sea by Chinese and foreign ships and oil platforms according to the law.

The monitoring has proved that the environment in the oil-polluted Bohai Sea in North China has improved and heavy-metal pollution in the coastal sea waters reduced.

A leading official of the bureau told the meeting that although much progress has been made in marine environmental protection, illegal dumping of pollutants into the sea still takes place.

He said this year his bureau would put more teeth into the marine protection law by organizing more ships and planes to monitor the marine environment and deal seriously with cases of marine pollution.

The bureau, he said, will also work out regulations concerning waste dumping along the coastal areas, and patrol the country's fishing grounds to safeguard China's marine rights and protect fisheries.

Aerial remote-sensing technology will be applied to the marine environmental monitoring this year, he added.

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ENVIRONMENTAL QUALITY

CHINA DRAWS UP EMERGENCY PLANS FOR MARINE POLLUTION

OW031222 Beijing XINHUA in English 1203 GMT 3 Mar 86

[Text] 3 March Beijing (SINHUA)--China has completed its study on prevention, control, and response to marine pollution, and is drawing up an emergency response plan for such pollution, an official of the State Bureau of Environmental Protection said here today.

Sun Jiamian, deputy director of the bureau, said that besides this national contingency plan, China will also work out regional emergency plans, plans for bays and harbors, and for offshore oil exploration and exploitation, as well as conclude agreements with neighboring countries.

Sun made these remarks at the opening ceremony of a week-long workshop on marine pollution prevention, control, and response jointly sponsored by Chian's Ministry of Communications, the State Bureau of Environmental Protection and the International Maritime Organization.

Sun said that quite a few oil spills had occurred in Chinese waters over the past few years and had caused damage to the country's marine biological resources, tourism, and various economic and social activities with considerable economic losses.

The Chinese government, he said, attaches great importance to marine environmental protection and has promulgated the Marine Environment Protection Law and administrative rules and regulations.

The country has established organs for marine administration, built up an "army of specialists," and strengthened supervision and control of marine pollution.

Sun said that China hopes to increase its contacts and exchanges with relevant international organizations.

Seven specialists from the International Maritime Organization attended today's opening ceremony and will give lectures to about 100 professionals from all over the country.

Ramesh P. Upadhyay, deputy resident representative of the United Nations Development Program, and [word indistinct] of the Chinese Ministry of Communications were also present at today's meeting.

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STUDY OF X-RAY PREIONIZED XeCl EXCIMER LASER

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 5 No 5, Oct 85 pp 201-203

[Article by Tang Shiqing [0781 1102 3237], Yuan Yifeng [5913 0001 7364], Deng Huihua [6772 1920 5478], and Ding Ze'an [0002 3419 1344] of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Abstract] In ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS], Vol 10 No 3, 85 p 152, the authors reported experimental results of excimer laser by using spot light source X-rays as the preionization source. In order to increase equipment service life with a compact structure, the authors used large-area cold-cathode transmission-type narrow-pulse (less than 200 ns) X-rays as the preionization source, and the conventional C804 capacitor instead of the panel transmission line; a better effect was achieved. The effects of charge voltage and discharge time delay on the puncture voltage, rate of rising discharge voltage, output light-pulse energy and equipment efficiency as well as the laser output have been studied for a modified X-ray preionized XeCl excimer laser. The delay characteristics curve of 0-700 ns was given in one of seven figures. Six other figures show the experiment setup, discharge voltage waveforms, as well as charge voltage on the one hand, and laser pulse energy, rate of rising discharge voltage, laser output and equipment efficiency on the other. The paper was received for publication on 1 February 1985.

IMPROVEMENT OF KrCl EXCIMER LASER

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 5 No 5, Oct 85 pp 204-206

[Article by Jiang Baocai [5592 1405 6299], Leo Yuekang [2867 6460 1660] and Yuan Cailai [5913 2088 0171] of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, and Zhang Yibin [1728 1837 1755] of Northeast Telecommunication Engineering College]

[Abstract] For the excimer laser to be practical, there should be compact equipment with reliable performance and low cost. In this paper, an ultraviolet (UV) preionized discharge excited KrCl (λ=222 nm) excimer laser with concentrated-parameter ceramic industance-free capacitance is reported. The single-pulse output energy is over 63 mJ. In four of nine figures, experiments show that the output energy of the KrCl excimer laser is closely related to charge voltage, total gas pressure, and Kr content. Five other figures show transfer and equivalent circuits of a capacitor, testing setups for energy measurement and voltage waveform, far and near field output laser spots, and a voltage waveform curve. The paper was received for publication on 28 March 1985.

OUTPUT CHARACTERISTICS OF CASCADE ULTRASHORT CAVITY DYE LASERS

Shanghai YINGYONG JIGUANG [APPLIED LASER] in Chinese Vol 5 No 5, Oct 85 pp 207-210

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[Abstract] In this paper, the dependence of output spectral characteristics of a cascade short-cavity dye laser on pumping wavelengths and concentration of dyes is reported. The experimental results are also described: a second harmonic nanosecond pulse from a Q-switch ruby laser converted into a tunable subnanosecond pulse by a transient technique of a Roess-Lin resonator. As shown by experiments, the cascade pumping ultrashort-cavity operation style can extend the tuning range of the light spectrum, and obtain light pulses compressed to picoseconds. If operated with a multistage cascade pumping method, ps (the limit of photon lifespan in a cavity) light pulser can be obtained from ns pulses. Eight figures show the experimental setup, output light spectra of cascade ultrashort cavity, light pulse waveforms of various-stage outputs of cascade ultrashort cavity, relationship between laser output spectra and cavity length, relationships between laser output central wavelength and increment bandwidth on the one hand, and pumping light wavelength and dye concentration on the other, relationship between laser tuning wavelength and piezoelectric ceramic voltage, and the relationship between dye laser pulse width and output power on the one hand, and the power of pumping light on the other. The paper was received for publication on 17 March 1985.

FLASH PUMPED PICOSECOND DYE LASER

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[Article by Wang Shuicai [3769 3055 2088] and Shi Ke [0670 3784] of Xian Institute of Optics and Precision Mechanics, Chinese Academy of Sciences]

[Abstract] A high efficiency flash pumped picosecond dye laser is described. A 1.5 x 10^{-4} M R 6G is used as the lasing medium; a 1 x 10^{-4} M DODCI is used as the mode-locked dye. Laser pulses with duration of 2-5 ps and power of megawatts at a wavelength of 580-620 nm can be obtained. The output of the flash pumped ps dye laser is sequence pulse with pulse width narrower and narrower along with sequence to 2 ps as the narrowest pulse width. The authors used a BWS-5K image changing tube ps scanner to measure the laser pulse with its setup shown in one of five figures. The mode-locked pulse sequence is shown in another figure while its sequence envelope is shown in a third figure. The laser pulse was obtained with a model BWS-5K image changing tube ps scanning camera. The remaining figure shows the principle of the experimental setup for a flash pumped ps dye laser. The paper was received for publication on 2 April 1985.

OPTIMUM CHARGE OF SOLID-STATE PULSED-LASER POWER SUPPLY

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[Article by Ning Xifa [3942 0823 4099] and Yao Jianquan [1202 1696 6898] of Department of Precision Instruments Engineering, Tianjin University]

[Abstract] The optimal charge process is analyzed for raising charge efficiency. The optimal charge time is formulated for a practical charge circuit. Mathematical equations are derived for analysis of the optimal charge process and time: heat loss in the circuit, energy loss at constant-current charge, circuit current, total loss during charge period, minimum loss during optimal charge time, and the charge efficiency. The only figure shows a charge circuit for constant-current power source in order to adjust the voltage as the optimal output voltage within a charge period by raising the charge efficiency. The paper was received for publication on 7 March 1985.

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